I. INTRODUCTION

On June 15, 1993, Massachusetts Electric Company ("MECo" or "Company") filed its 1992 DSM Performance Measurement Report ("M&E Report" or "Report") with the Department of Public Utilities ("Department"). The Report and its accompanying appendices provide descriptions of the Company's impact and process evaluation results[1] for its 1992 demand-side management ("DSM") programs. The results of these evaluations are used by the Company and the Department for planning purposes and for determining the DSM incentive earned by the Company in 1991 and 1992.

The impact evaluations included in the M&E Report contain estimates of savings resulting from measures installed in 1991 and 1992. The Company's determination of DSM savings estimates in a particular year is based on a four-step process (Exh. DPU-1, at I-1). First, initial estimates of program savings are determined in advance of the program year, using engineering calculations of savings per energy conservation measure ("ECM") and projections of how many measures of each type will be installed.[2] These initial estimates are presented to the Department to project program cost-effectiveness (id.). Second, at the end of each program year, the Company updates its initial savings estimates to reflect the actual number of ECMs installed in that year; the Company refers to these updated estimates as

---

[1] Impact evaluations use quantitative analyses to assess energy and capacity savings resulting from the implementation of DSM programs. Process evaluations focus on qualitative issues such as program design and operational efficiency. Massachusetts Electric Company, D.P.U. 90-261, at 99 (1991).

[2] The initial savings estimates may be informed by previous evaluations. For example, MECo's initial savings estimates for 1992 and 1993 were based on impact evaluation activities undertaken in 1990 and 1991 (Exh. DPU-1, at I-1).

"tracking estimates" (id.). Third, the Company conducts a first round of post-installation measurements to provide more accurate estimates[3] of the energy and capacity savings resulting from the installation of the ECMs. MECo refers to these measurements as the First Look evaluation of savings, which are submitted in June of the year following the program year when those measures were installed (id.). Finally, the Company conducts a second round of post-installation savings measurements, referred to as the Second Look evaluation of savings. The Second Look savings estimates replace the First Look estimates since they are based on more complete data that are sometimes collected through a full year of post-installation measurements. The Second Look evaluations are submitted to the Department one year after the First Look evaluations (id.).[4]

The M&E Report contains the First Look savings estimates for ECMs installed in 1992 and the Second Look savings estimates for ECMs installed in 1991.[5] Based on the First Look savings estimates contained in the M&E Report, MECo has proposed recovery of

---

[3] The Department has recognized that kilowatts and kilowatthours saved by DSM programs are not as easily measured as kilowatts and kilowatthours generated or consumed. Massachusetts Electric Company, D.P.U. 90-261, at 100 (1991). Because DSM savings cannot be measured exactly, savings measurement results are referred to as savings estimates.

[4] Pursuant to the terms of the Settlement approved by the Department in Massachusetts Electric Company, D.P.U. 91-205 (1992), the Company's 1992 DSM preapproval proceeding, MECo is required to conduct a Second Look evaluation of 1992 program savings only if the 1991 Second Look savings estimates differ from the 1991 First Look estimates by more than 20 percent. D.P.U. 91-205 Offer of Settlement at 5.

[5] The Company states that more than 90 percent of the energy savings and 80 percent of the capacity savings from measures installed in 1991 were re-evaluated as part of its 1992 impact evaluation activities (Exh. DPU-1, at I-1).

a 1992 after-tax incentive of $4,663,534 (id. at II-1).[6] In addition, based on the Second Look savings estimates contained in the M&E Report, MECo has proposed a revised 1991 after-tax incentive of $7,750,753, an increase of $884,248, or 13 percent, over the after-tax amount determined from the First Look savings estimates for 1991 (id.).[7] Table 1 summarizes the results of the impact evaluations contained in the M&E Report.

In this Order, the Department addresses whether the savings estimates included in the Company's 1992 impact evaluations satisfy the criteria established by the Department for the review of such evaluations.[8] Because the Company's incentive payments associated with the implementation of DSM programs during 1991 and 1992 are based on the savings estimates included in the impact evaluations, the Company may be required to recalculate the incentives to reflect the directives in this Order.[9]

---

6 The after-tax incentive amount is based on a formula approved by the Department in Massachusetts Electric Company, D.P.U. 91-205. D.P.U. 91-205 Offer of Settlement, Section B. This amount represents $7,673,442 before taxes. Massachusetts Electric Company, D.P.U. 92-217-A Offer of Settlement, Attachment 7, at 6. Pursuant to D.P.U. 91-205, the Company shall recover the 1992 incentive through its conservation charge ("CC") rates. D.P.U. 91-205 Offer of Settlement, Section C.

7 Pursuant to D.P.U. 91-205, the Company shall recover any increase in its 1991 incentive through its Fuel Adjustment Factor. D.P.U. 91-205 Offer of Settlement, Section C.

8 The Department does not address in this Order the process evaluations included in the M&E Report. The Department notes that companies are expected to consider all recommendations contained in the process evaluations and to revise program designs to reflect those recommendations that the companies consider to be appropriate.

9 Pursuant to the Department's Order in D.P.U. 90-261, the Company's 1991 incentive shall be recalculated based on the Department's findings with regard to 1991 savings estimates. Id. at 79-80. Pursuant to the Offer of Settlement in D.P.U. 92-217-A, the Company's 1992 incentive shall be recalculated following the Department's Order on MECo's 1992 DSM Performance Measurement Report. Id. at 2.

TABLE 1. SUMMARY OF 1991 AND 1992 DSM ACTIVITIES

	1991	1992
Total DSM Expenditures	$ 55.1 million	$ 43.6 million
Energy Savings, Annual	150 GWH	109 GWH
Fraction of Energy Sales	1.0%	0.7%
Capacity Savings, Annual	40 MW	32 MW
Fraction of Peak Demand	1.4%	1.1%
Lifetime Energy Savings	2513 GWH	1,455 GWH
DSM Expense / Total Revenue	4.1%	3.2%
Benefit/Cost Ratio	3.13	2.71
DSM Incentive / Net DSM Value	5.7%	6.9%
DSM Cost	2.5 ¢/KWH	2.8 ¢/KWH

Note: "GWH" stands for gigawatthour, which equals 1 million kilowatthours ("KWH"). "MW" stands for megawatt, which equals 1,000 kilowatts ("KW").

(Exhs. DPU-123; DPU-1, at I-10, I-11, A-2, B-3).

II. STANDARD OF REVIEW

The Department has established the criteria to be used in the review of electric companies' DSM impact evaluations through a series of previous orders. To ensure the reliability of the savings estimates produced by the impact evaluations, the Department has directed companies to minimize bias in the savings estimates. Boston Edison Company, D.P.U. 90-335, at 105 (1992) ("BECo"); Western Massachusetts Electric Company, D.P.U. 91-44, at 140, 143 (1991) ("WMECo"). The Department has found substantial bias in engineering estimates of DSM savings and, accordingly, generally has required companies

to measure savings after the installation of ECMs.[10] BECo at 106; Nantucket Electric Company, D.P.U. 91-106/138, at 212-215 (1991); Massachusetts Electric Company, D.P.U. 90-261, at 79, 80, 85 (1991) ("MECo"); WMECo at 142-143.

The Department has identified some sources of bias in savings estimates, including: (1) poor selection of samples used in savings measurement analyses, WMECo at 138; (2) inaccurate hours-of-use estimates, BECo at 105; WMECo at 142; MECo at 109, 110; (3) the failure to account for free riders, BECo at 111-112; (4) the failure to account for interactions of multiple DSM measure installations, Cambridge Electric Light Company and Commonwealth Electric Company, D.P.U. 89-242/246/247, at 78-79 (1990) ("ComElectric")); and (5) overestimated persistence of savings, BECo at 110-111; WMECo at 147-148.

The Department has recognized that, in certain instances, the costs of obtaining more precise estimates of savings may exceed the incremental value of those more precise estimates. MECo at 100. Therefore, the Department has directed companies to pursue savings measurement activities that maximize the level of precision of the DSM savings estimates, but only to the extent that the marginal value of the more precise savings estimates exceeds the marginal cost of obtaining the additional precision. BECo at 100-103, 110; MECo at 106, 108.

The Department will accept savings estimates if it can be determined that they are

---

[10] The Department has allowed savings estimates which are not based on after-the-fact measurement for programs in which (1) only one well-defined end use is involved and the hours of operation of the installed ECMs are very predictable or controlled by a company, or (2) it can be demonstrated that no after-the-fact measurement is possible. MECo at 109; BECo at 109, n.40; WMECo at 142.

sufficiently unbiased and sufficiently precise, given the nature of the program, the company's resources, and the costs and value of obtaining better precision.[11]

The Department notes that this is the first comprehensive, post-installation review of a company's DSM impact evaluations. As part of this review, the Department will apply the review criteria described above. However, in future impact evaluation reviews, the Department expects to apply a standard of review that is consistent with Department precedent in this area, but which also reflects the criteria that have been established for the review of electric companies' demand forecasts. This is appropriate because, similar to electric demand forecasts, DSM impact evaluations employ input data and complex methodological techniques to develop assessments that are important to the utilities' resource planning processes and to ratepayer costs. Therefore, in future reviews, the Department will accept the savings estimates that are a product of an electric company's impact evaluations if the company demonstrates that the impact evaluations are reviewable, appropriate, and reliable. A company's impact evaluation filing will be considered reviewable if the record is complete, clearly presented, and contains a summary that sufficiently explains all assumptions and data presented. An impact evaluation will be considered appropriate if evaluation techniques selected are reasonable given consideration of the characteristics of a particular DSM program, the company's resources, and the available methods for

---

[11] The Department notes that this standard of review applies specifically to the review of a company's savings estimates and not to the review of any expenses for which recovery may be sought through a conservation charge. The ratemaking treatment to be afforded revenue entitlements calculated based on the savings estimates (i.e., lost base revenues and incentives) is addressed more appropriately in a conservation charge proceeding.

determining demand and energy savings estimates.[12] Finally, the savings estimates included in an impact evaluation will be considered reliable if the estimates are sufficiently unbiased and are measured to a sufficient level of precision, again, given consideration of the characteristics of a particular DSM program, the company's resources and the available methods for determining demand and energy savings estimates. Interested parties will have the opportunity to comment on this standard of review in future proceedings.

III. DESCRIPTION OF DSM SAVINGS ESTIMATION TECHNIQUES

A. Introduction

As stated in Section I, above, the energy and capacity savings estimates produced by the impact evaluations are used by the Company and the Department for planning purposes and for determining the DSM incentive earned by the Company in a particular year. In order to serve these purposes, the impact evaluations must produce savings estimates that reflect (1) the period of time over which the ECMs can be expected to generate savings (i.e., "lifetime" savings estimates), (2) the level of demand savings that occurs at the time of, or coincident with, a company's peak power demand (i.e., "coincident" demand savings),[13] and (3) do not include the level of savings that would have occurred in the absence of

---

[12] The Department recognizes that the state-of-the-art in methods used to determine DSM savings estimates is evolving and expects companies to remain up to date with technological and methodological advances in this field.

[13] Savings estimates that do not take into account the level of demand savings that occurs at the time of a company's peak power demand are referred to as "non-coincident" demand savings estimates.

implementation of the DSM programs (i.e., "net" savings estimates).[14] To determine net savings estimates, gross savings estimates must be adjusted to take into account non-program factors that may affect the electricity consumption of program participants. These factors include free-ridership,[15] spillover (additional savings that are induced by a DSM program), economic conditions (both general and firm-specific),[16] and weather.

The first step in developing energy and capacity savings estimates consists of producing engineering estimates of the savings, based on the number of ECMs installed. As stated in Section II, above, the Department has generally required companies to measure actual savings after the installation of the ECMs. Post-installation measurement techniques typically measure the savings for a sample of program participants in a particular year (the "participant group"). The results of the post-installation measurements typically are applied to the entire population of program participants in two steps. First, the measured savings estimates for the participant group are compared to the engineering estimates of savings for that same group. The ratio of the measured savings estimates to the engineering savings

---

[14] Savings estimates that include the level of savings that would have occurred in the absence of implementation of the DSM programs are referred to as "gross" savings estimates.

[15] A free rider is defined as a program participant who would have installed an ECM without direct payment from an electric company. D.P.U. 86-36-F at 25-26. A pure free rider would have spent the same amount of money to install the same energy-efficient measures at the same time without benefit of a utility company's program. A partial free rider would have spent less money, installed less equipment, installed only somewhat efficient equipment, and/or installed the equipment at a later date.

[16] Firm-specific economic conditions may include changes in floorspace, equipment, hours of operation, industrial process configuration, output, employment, and/or sales.

estimates is referred to as the "realization rate". Second, the engineering-estimated savings for the entire population of program participants are multiplied by the realization rate to determine savings estimates for the program. Depending on the post-installation measurement techniques used, these savings estimates may need to be adjusted to reflect (1) revisions to the period of time over which the ECMs can be expected to generate savings (i.e., adjustments for "savings persistence") and (2) non-program factors that might affect customers' electricity consumption (i.e., adjustments for net savings).

The following sections describe the savings estimation techniques most commonly implemented by companies at the present time. These techniques are engineering estimates, billing analysis, end-use metering, use of load-shape data, and surveys.

B. Engineering Estimates

Engineering estimates of annual capacity savings are determined in two steps. First, non-coincident demand savings estimates are developed based on (1) the number of ECMs installed, and (2) the difference between the power consumption, as expressed in kilowatts ("KW"), of the installed ECMs and the power consumption of alternative equipment. For retrofit applications, the power consumption of the equipment replaced by the ECMs serves as the basis for the demand savings calculation. For new construction, renovation, and remodeling applications, the demand savings calculation generally is based on the power consumption of standard-efficiency equipment that meets the standards established by building codes. Second, these estimates are adjusted by a coincident demand factor that reflects the level of demand savings that occurs at the time of a company's peak power demand.

Engineering estimates of annual energy savings are developed based on the annual non-coincident demand savings estimates and the projected hours of use of the ECMs, which generally are based on operational data reported by program participants. For ECMs whose power consumption is constant (e.g., lighting measures, ordinary motors), energy savings estimates can be calculated simply as the product of the annual reduction in non-coincident demand and the projected hours of use of those measures. For ECMs whose power consumption varies, (e.g., heating, ventilation, and air conditioning systems, variable speed drive motors, and some industrial processes) the calculation of energy savings estimates requires that one takes into account the varying levels of power consumption; computer simulations are often required to determine energy savings estimates for these ECMs.

Engineering estimates of lifetime capacity and energy savings are calculated as the product of the engineering estimates of annual savings and the projected number of years over which the ECMs can be expected to generate savings, which generally are determined from manufacturer specifications.

Finally, to determine engineering estimates of net capacity and energy savings, the gross engineering estimates described above must be adjusted to take into account non-program factors that may affect the electricity consumption of program participants.

C. Billing Analysis

The simplest form of billing analysis compares the pre-installation energy consumption of a group of program participants (the "participant group"), as indicated by

customer bills, to the post-installation energy consumption of the same group.[17] The difference in energy usage between the two periods[18] is determined to be the gross annual savings that are attributable to the implementation of the DSM program.[19] Lifetime gross savings estimates are calculated as products of the annual savings estimates and the projected lifetimes of the installed ECMs.

As stated above, gross savings estimates need to be adjusted to account for non-program factors that might affect energy consumption in the post-installation period to determine net savings estimates. In order to produce net savings estimates, billing analyses may include a similar group of customers who have not participated in the DSM program (the "comparison group"). The comparison group provides information regarding what the energy consumption of program participants would have been in the absence of participation in the DSM program. Thus, billing analyses that include comparison groups can account for factors unrelated to the DSM program that affect energy consumption and, thus, may produce net savings estimates. In these analyses, the pre- and post-installation energy consumption of the participant group is compared to the pre- and post-installation energy consumption of the comparison group. Net energy savings estimates are determined by

---

[17] Billing analysis relies on data from billing meters, which record energy consumption for all customers. For those customers whose billing meters record demand consumption (i.e., some large commercial and industrial customers), billing analyses can produce estimates of demand savings.

[18] The pre- and post-installation periods need to be long enough to account for variations (e.g., weather-related) in energy consumption.

[19] The precision of the savings estimates is determined statistically as a function of the number of customers included in the analysis (i.e., the sample sizes) and the variation in energy consumption among the sampled customers.

subtracting the average decrease in energy consumption for the comparison group from the average decrease in energy consumption for the participant group.[20]

The process by which the customers included in the participant and comparison groups are selected will influence the accuracy of savings estimates produced by a measurement technique. Stratification of the participant and comparison groups is a technique that can aid in selecting a participant group that is representative of the total population of program participants and in selecting a comparison group that will best reflect the savings that would have been achieved by the participant group had ECMs not been installed.[21]

Where selection of a comparison group that closely matches the participant group is difficult because of the diversity in the characteristics of program participants, a statistical technique called regression analysis commonly is applied to the billing data of participant and comparison groups. A regression analysis involves the construction of an equation in which the value of a dependent variable (e.g., change in energy consumption), is "predicted" by several independent variables (e.g., engineering estimate of the energy savings, firm size, heating degree days) for each "observation" (e.g., customer or month). The independent variables are selected to include factors unrelated to the DSM program that may affect

---

[20] Alternatively, net energy savings may be determined by applying the ratio of post- to pre-installation energy consumption for the comparison group to the difference in energy consumption over the same periods for the participant group.

[21] Customers can be stratified (i.e., sorted and assigned to categories) by level of energy consumption, household size, expected energy savings, business type, etc. Stratification also may be used to assign different weights to various members of the participant and comparison groups. This practice may improve the degree to which small samples of customers represent the population of program participants.

post-installation energy consumption; thus, regression analyses may produce net savings estimates. Regression analysis works by minimizing the sum of the squares of the differences (commonly referred to as "residuals") between the values of the dependent variable predicted by the regression equation and the actual values. The result of such an analysis is a set of estimates of the influence of each independent variable (as represented by the "coefficients" of the independent variables) on the dependent variable. The extent to which the dependent variable is accurately predicted by the regression equation commonly is represented by two statistics: (1) R^2, which indicates the extent to which the variation in the dependent variable is explained by the regression equation; and (2) a t-ratio for each independent variable, which suggests the probability that the independent variable truly affects the dependent variable and is used to estimate the precision of the independent variable's estimated effect.[22] Many regression analyses of energy consumption use the engineering estimate of energy savings as one of the variables which explain changes in energy consumption; in these cases, the coefficient for the engineering estimate is the realization rate. Most other regression analyses (usually for programs in which each participant is expected to achieve a similar amount of savings) use program participation in place of the engineering estimate of savings; in this case, the coefficient for the participation variable is the estimated savings per participant, which can then be compared to the expected savings per participant to estimate the realization rate.

---

[22] The coefficients, R^2, and t-ratios vary according to which independent variables are included in the regression equation and which data observation points are examined.

D. End-Use Metering

End-use meters typically measure the pre- and post-installation power consumption and/or hours of operation of a single piece of equipment, a circuit with several pieces of similar equipment, or a whole building to determine the reduction in demand resulting from a DSM program. The length of time that an end-use meter is employed depends on the operating characteristics of the ECMs being metered. For ECMs whose power consumption and/or hours of use are constant, end-use meters may be employed for a short period of time; for ECMs whose power consumption and/or hours-of-use varies, end-use meters should be employed over a period of time that captures the variation in power consumption and/or hours-of-use. In addition, if end-use meters are used to determine coincident demand savings, then the meters must record power consumption data at the times of a company's peak power demand.

Compared to billing analysis, end-use metering has several advantages and disadvantages. Advantages include the ability to (1) isolate actual use and load patterns of the particular ECM installed from changes in other loads, and (2) measure KW savings, which few billing meters can do. Disadvantages include (1) much higher costs per meter than billing analysis, and (2) inability to detect interactions among energy-using systems.[23] Because of the high cost associated with end-use meters, typically only a few facilities or pieces of equipment are metered. This has two ramifications. First, the sample of ECMs selected for metering must be representative of the ECMs installed through a program. Second, because comparison groups are not usually included in this type of analysis, end-use

[23] For example, more efficient lights emit less heat, so space cooling needs are reduced.

metering typically produces gross savings estimates; other methods are then required to estimate what would have occurred absent the DSM program.

Because end-use meters can isolate the impact of particular ECMs from other changes at a facility, a technique called ratio estimation sometimes can be used to obtain greater precision from a small sample than techniques used with billing analysis can, compensating for the small sample size dictated by the cost of metering. Ratio estimation techniques resemble regression analysis with one independent variable (the engineering estimate of savings), but utilize ratios of equipment-specific measured savings to the engineering estimates, in place of the differences.

E. Load Shape Data and Surveys

Load shape data[24] are sometimes used in estimating capacity savings. Load shape data show the amount of relative power consumption[25] by various kinds of equipment, in various settings (e.g., restaurants, offices, warehouses) by time of day. Estimates of energy savings derived from billing analysis can be multiplied by appropriate factors from load shape curves to derive estimates of capacity savings.

Survey data can be applied to engineering analyses, billing analyses, and end-use

---

[24] Load shape data generally are based on end-use metering by a demand forecasting division or by another utility, rather than by a utility's own DSM division; they are not derived from measuring ECMs in a DSM program.

[25] For example, the pattern for consumption by a water heater may show a range in hourly use from 0.1 to 1.0, with a sharp peak at 7 A.M. and smaller peaks at noon and 6 P.M. A refrigerator's hourly pattern, on the same scale, might be 0.9 to 1.2, with a slight peak at noon. Lights might consume from 0 to 2.5 on the same scale, with a broad peak from 6 P.M. to 10 P.M., and no use from midnight to 5 A.M. This load shape data includes power consumption, energy use, and coincidence factors.

metering analyses. Some surveys consist of ECM inspections, while others consist of questionnaires. Surveys may be used to estimate free riders, hours of use, coincidence factors, persistence, and inputs for computer simulation models of complex equipment systems. Thus, survey data can be used to convert gross savings estimates to net savings estimates, demand savings to energy savings, demand savings to capacity savings, annual savings to lifetime savings, and for other purposes.

IV. THE COMPANY'S DSM IMPACT EVALUATIONS

A. Introduction

The Company submitted impact evaluations for all of the DSM programs that it implemented during 1992 (Exh. DPU-1, at I-3). Programs targeting the commercial/industrial ("C/I") sector include the Energy Initiative, Design 2000, and Small Commercial and Industrial Programs. Programs targeting the residential sector include the Residential Electric Space Heat, Residential Lighting, Home Energy Management, Multi-Family, Energy Fitness, Water Heater Rebate, and Energy Crafted Home Programs (id.). Table 2 provides a comparison of the 1992 First Look savings estimates for each program with the savings estimates determined from engineering calculations and the number of ECMs installed (i.e., the tracking estimates). Table 3 provides a comparison of the 1991 Second Look savings estimates for each program with the 1991 First Look savings estimate reported last year.

The Department separately reviews each program's impact evaluation, with the exception of the Energy Initiative ("EI") and Design 2000 Programs. Since the end uses addressed by the EI and Design 2000 Programs are similar, MECo applied the results of the

impact evaluation studies for these end uses to both programs. Therefore, the Department jointly reviews the impact evaluations for the EI and Design 2000 Programs.

B. The Commercial/Industrial Sector

1. EI and Design 2000 Programs

a. Introduction

The Company began implementation of the EI and Design 2000 Programs in 1989 (Exh. DPU-1, at IV-1). Both programs are designed to address electrical efficiency opportunities at the facilities of medium and large commercial, industrial, and government customers, through the installation of comprehensive ECMs.

The EI Program targets equipment retrofit projects at existing facilities. The Company stated that 767 customers participated in this program during 1992, and reported First Look annual energy savings estimates of 44,702 megawatthours ("MWHs") and annual capacity savings estimates of 9,438 KWs for ECMs installed during 1992 (id. at IV-2). In addition, the Company reported Second Look annual energy savings estimates of 125,477 MWH and annual capacity savings estimates of 28,122 KW for ECMs installed during 1991 (id. at B-1).

The Design 2000 Program targets new construction/renovation projects. The Company stated that 336 customers participated in this program during 1992, and reported First Look annual energy savings estimates of 30,243 MWHs and annual capacity savings estimates of 7,015 KW for ECMs installed during 1992 (id. at III-2). In addition, the Company reported Second Look annual energy savings estimates of 6,556 MWH and annual capacity savings estimates of 1,513 KW for ECMs installed during 1991 (id. at B-1).

End uses addressed through both programs during 1992 included interior and exterior lighting and lighting controls, variable speed drive motors, other motors, custom and process equipment, refrigeration, building shells, and heating, ventilation, and air conditioning systems and controls (id. at III-2, IV-2). Table 4 summarizes the energy savings reported by the Company for each end use. The Department separately reviews the impact evaluation studies for each end use. With the exception of lighting measures, the Department's review does not distinguish between ECMs installed in the EI Program and ECMs installed in the Design 2000 Program.

b. Lighting Measures

i. EI Program

(A) Description

The Company developed energy savings estimates for lighting measures installed through the EI Program based on the results of a regression analysis of electric bills from samples of program participants and non-participants (Exh. DPU-1, at IV-13). As stated in Section III.C, above, a regression analysis involves an equation in which several independent variables are used to "predict" the value of a dependent variable. In the regression equation used to determine lighting savings estimates for the EI Program, the dependent variable was the 1992 energy consumption (i.e., post-ECM-installation) of the participants and non-participants (id. at IV-14). The Company stated that it selected thirteen independent variables to be included in the regression equation. One of the independent variables was the engineering savings estimates for lighting measures installed during 1991 (the value of this

variable was zero for non-participants).[26] The other independent variables were selected to account for various factors unrelated to the program that might have affected energy consumption for the participants and non-participants during the post-installation period (id. at IV-14 through IV-16).[27]

The Company stated that it applied its regression equation to billing data of 589 customers who participated in the program during 1991 (the "participant group") and 593 non-participants (the "comparison group") (id., App. K at 2-15).[28] The Company stated that the regression equation produced coefficients on the independent variables that accurately predicted the 1992 energy consumption for the members of the participant and comparison

---

[26] The Company stated that the coefficient on the engineering estimate variable represented the realization rate for savings resulting from the installation of lighting measures (Exh. DPU-1, at IV-17).

[27] The other independent variables reflected, for each customer included in the analysis, (1) 1990 (i.e., pre-installation) energy consumption, (2) decreases in electrically heated space, (3) worsening business conditions, (4) increases in interior lighting fixtures, (5) increases in total number of employees, (6) the total number of employees, (7) ECMs installed outside of the Company's DSM programs, (8) the addition of electrical equipment, (9) decreases in air conditioned space, (10) whether the facility was a retail facility, (11) whether the facility was an office facility, and (12) participant self-selection bias (Exh. DPU-1, at IV-15, 16). The Company stated that information regarding the independent variables was collected from the sampled customers through surveys (id.).

[28] The Company stated that, to be included in the participation group, a customer must (1) have installed lighting measures through the EI Program during 1991 only; (2) have not participated in another DSM program during the years 1990 through 1992; (3) have had complete electricity billing records for the years 1990 through 1992; and (4) have completed the survey regarding the information reflected in the independent variables of the regression equation (Exh. DPU-1, App. K at 2-8 through 2-15). The Company stated that the customers included in the participation and comparison groups were sufficiently representative of the population of 1991 EI participants (id. App. K at 2-16).

groups (id. at IV-15).[29] Based on the results of the regression analysis, the Company reported a realization rate of 70 percent.[30] The Company noted that the 70 percent realization rate produced by the regression analysis was consistent with a 72 percent realization rate estimated by its end-use metering activities described below for this program (id., at IV-17; App. L at 2; Exh. DPU-28).

In response to information requests issued by the Department, the Company tested the sensitivity of the results of the regression model to different sets of independent variables and the dependent variable by constructing several regression equations in which the independent variables were changed (Exhs. DPU-2; DPU-26; DPU-133). The realization rates produced by these alternative equations ranged from 65 percent to 73 percent; most of the equations had statistical properties (e.g., t-ratios) comparable to the equation used by the Company (id.).

In addition, the Company tested the sensitivity of the results of the regression model to different subsamples of data observations by examining five different sets of participant

---

29 As described in Section III, above, the extent to which the value of the dependent variable is predicted by the independent variables in a regression equation is represented by two statistics, R^2 and t-ratios. T-ratios greater than ± 2 indicated that about half of the independent variables in the Company's analysis were significant (Exh. DPU-1, at IV-15). The R^2 statistic indicated that the Company's analysis explained 99 percent of the variation in the level of energy consumption (id.). However, the Company's analyses explained no more than 36 percent of the variation in the change in energy consumption (Exh. DPU-26).

30 The Company stated that the precision level of the savings estimates was ± 44 percent at the 90 percent confidence level; i.e., there was a 90 percent probability that actual savings were within 44 percent of the estimated savings level (Exh. DPU-1, App.C).

and comparison group members (Exh. DPU-1, App. K at C-1).[31] The Company stated that the purpose of the sensitivity study was to examine the effect on the results of the regression analysis of data observations that could be characterized as data outliers (i.e., data observations with large error terms, or residuals[32]) or leverage points (i.e., data observations identified as having a particularly strong influence on the results of the analysis).[33] The realization rates that resulted from these five regressions ranged from 27 percent to 114 percent (id., App. K at C-2, 3). The Company stated that, because (1) there are no well-defined and universally accepted criteria for what constitutes either a data outlier or a high leverage point and (2) there did not appear to be any data entry or measurement errors associated with the billing data of these customers, there was no firm basis for excluding any of these data observations from the analysis (id.). The Company stated that it will conduct a Second Look evaluation of 1992 lighting savings for this program as part of its 1993 impact evaluation activities in order to examine further the issues surrounding the appropriate selection of data observations (id.).

---

31 For the purposes of this analysis, a data observation refers to the 1992 energy consumption of one participant or comparison group member.

32 As stated in Section III above, a residual refers to the difference between the actual value of the dependent variable and the value predicted by the regression equation.

33 The five different sets of participant and comparison group members reflected the removal from the analysis, respectively, of (1) approximately one-half of the data observations, consisting of data outliers or high leverage points; (2) 40 data observations that represented high leverage points; (3) eight data observations that represented extreme outliers; (4) one very large data observation, which consumed three times as much electricity as the next largest observation; and (5) the eight data observations that represented extreme outliers and the one very large data observation (Exh. DPU-1, App. K at C-2).

The Company stated that, to determine the net energy savings estimate from lighting measures installed in the EI Program, it applied an adjustment factor equal to the realization rate of 70 percent to the engineering estimates of energy savings from lighting for the entire population of 1992 participants (id. at IV-21). The Company stated that it did not adjust the energy savings estimates to account for savings persistence or free riders, since the effect of these factors was accounted for in the billing analysis (id. at A-19).

To determine capacity savings estimates for lighting measures installed through the EI Program, the Company conducted end-use metering at the facilities of 33 program participants (id. at IV-17).[34] The end-use metering resulted in gross, non-coincident demand savings estimates that were 93 percent of the engineering estimates of lighting savings at those facilities (id. at 18). In addition, the end-use metering produced coincident demand factors of 73.3 percent for lighting savings achieved during the summer and 65.3 percent for lighting savings achieved during the winter (id.).[35]

The Company stated that it determined the gross capacity savings for the EI Program in three steps. First, it applied a non-coincident demand adjustment factor of 93 percent to the engineering estimates of demand savings for all interior lighting measures installed during 1992 (id. at IV-18 through IV-21). Second, it applied the summer and winter coincident

---

[34] The Company stated that, although participants in the sample had, on average, lower energy and demand savings, and higher hours of use, than the average program participant, none of these differences was statistically significant (Exh. DPU-1, App. L at 8).

[35] The Company reported the following precision for the savings estimates at the 90 percent confidence level: $\pm$6.6 percent for the non-coincident demand savings; $\pm$10.5 percent for the coincident summer demand savings; $\pm$13.8 percent for the coincident winter demand savings (Exh. DPU-1, at IV-18).

demand factors to the non-coincident demand savings estimates. Finally, the Company adjusted the coincident demand savings estimates to account for savings persistence (id.). To measure savings persistence, the Company surveyed 95 of the 1990 EI Program participants and 97 of the 1991 EI Program participants to determine the fraction of installed lighting measures that were still in place and functioning (id. at IV-18, 20). The surveys resulted in savings persistence estimates of 94 percent for 1990 installations and 89 percent for 1991 installations (id. at IV-20). The Company stated that, because the 1991 results were influenced by unusually high rates of demolition, remodeling, and vacancy, it considered the 1990 results to be more reflective of savings persistence and, thus, applied a factor of 94 percent to the coincident demand savings estimates to determine the gross capacity savings estimates (id.).

The Company stated that, to determine net capacity savings estimates for the EI Program, the gross capacity savings estimates were adjusted by free-ridership factors that were developed for various categories of lighting measures based on the results of surveys of EI Program participants conducted during 1992 (id. at IV-11, 21).

(B) Analysis and Findings

The record demonstrates that the Company used a regression analysis of the electric bills of selected program participants and non-participants to determine energy savings estimates for lighting measures installed in the EI Program. The record demonstrates that (1) the regression equation was found to be statistically predictive of 1992 energy consumption for the participant and comparison group members, (2) the realization rate for energy savings remained relatively constant (i.e., was stable) as the dependent variable and

the sets of independent variables that were included in the regression equation varied; and (3) the energy savings realization rate resulting from the regression analysis was consistent with the energy savings realization rate resulting from end-use metering at the sites of 1992 EI Program lighting installations. The record shows, however, that the realization rate for energy savings varied significantly (i.e., was not stable) as the sets of data observations that were included in the analysis were varied to account for data outliers and leverage points.

The Department finds that the Company, by selecting the independent variables that were included in the regression equation, appropriately accounted for a wide range of non-program factors that might have affected the post-installation electricity consumption of the customers included in the analysis. In addition, the Department finds that the energy savings estimates produced by the regression analysis takes into account persistence of energy savings and free ridership. Finally, the Department finds that the stability of the realization rate with respect to the variables included in the regression equation and the consistency between the realization rates of the regression analysis and the end-use metering indicates that the 70 percent realization rate used by the Company to determine energy savings estimates is reliable.[36] Therefore, the Department finds that the energy savings estimates produced by the regression analysis are sufficiently unbiased and were measured to a sufficient level of precision.

The record demonstrates that the Company determined the capacity savings estimates

---

[36] For the purposes of this proceeding, the Department accepts the set of data observations that were included in the regression analysis. The Department expects that the Company will address issues regarding the appropriate selection of data observations in its 1993 DSM Monitoring and Evaluation Report.

for lighting measures installed in the EI Program based on the results of end-use metering, adjusted for savings persistence and free-ridership factors. The Department previously has found that end-use metering is a "good data source" for determining capacity savings estimates. BECo at 107. The Department has identified poor selection of samples used in savings measurement analyses, overestimated savings persistence, and failure to account for free riders as three sources of bias in savings estimates. Id. at 110-112; WMECo at 138. The Department finds that the sample of participants selected for end-use metering were sufficiently representative of the total population of program participants. In addition, the Department finds that the Company appropriately accounted for savings persistence and free-ridership through its on-site inspections of lighting measures installed during 1990 and 1991 and its survey of program participants, respectively. Therefore, the Department finds that the capacity savings estimates reported by the Company are sufficiently unbiased and were measured to a sufficient level of precision. In future impact evaluations, however, the Company is directed to expand its assessment of lighting savings persistence to include the effect of any deterioration in the performance of the installed lighting measures, consistent with the Department's directive in MECo.[37]

Based on the above analysis, the Department finds that the 1992 impact evaluation for lighting measures installed in the EI Program satisfies the criteria established by the Department for the review of impact evaluations. Accordingly, the Department accepts the First Look savings estimates for lighting measures installed during 1992 and the Second

---

[37] In MECo, the Department approved the Company's plans to examine the deterioration in performance of the installed ECMs, in addition to determining whether the ECMs are still in place and operating. Id. at 110.

Look savings estimates for lighting measures installed during 1991.

ii. Design 2000 Program

(A) Description

The Company stated that, because new construction projects do not have pre-installation usage data, the determination of savings estimates resulting from lighting measures installed through the Design 2000 Program was based in large part on engineering estimates reflecting the lighting measures installed, modified by data collected regarding measure persistence and building operating schedules (Exh. DPU-1, at III-8).

The Company stated that it developed the 1992 capacity savings estimates for lighting measures installed through the Design 2000 Program based on engineering estimates of gross non-coincident demand savings, which were then adjusted for the coincidence of the demand savings and free riders (id. at III-11, 12). Engineering estimates of gross, non-coincident demand savings were calculated as the difference between the lighting demand that resulted from the installation of lighting measures in the program and the lighting demand that would have resulted from the installation of standard-efficiency lighting equipment, as determined from the standards established for lighting in the Massachusetts Building Code (id. at III-11). Summer and winter demand coincidence factors were developed for each lighting measure category based on the results of telephone interviews with customers who participated in the Design 2000 Program during 1992 (id., App. F at 2-3). To determine net capacity savings estimates, the Company adjusted the gross capacity savings estimates by free-ridership factors for lighting and lighting control measures, based on telephone surveys of 1992 Design 2000 participants (id. at III-10).

The Company stated that it developed the net energy savings estimates for lighting measures installed through the Design 2000 Program based on the net capacity savings estimates and hours-of-use estimates that were based on information reported by program participants (id. at III-12; Exh. DPU-58).

(B) Analysis and Findings

The record demonstrates that the Company determined demand savings estimates for lighting measures installed through the Design 2000 Program based on (1) engineering estimates that reflect the difference between the power consumption of energy-efficient lighting measures and the power consumption of standard-efficiency lighting measures; (2) demand coincidence factors based on telephone surveys of program participants; and (3) free-ridership factors based on surveys of the owners and managers of the participating facilities. The Department notes that the power consumption for lighting measures are relatively constant and relatively well-known; thus, engineering estimates of demand savings that are based on actual installations and current building code standards should produce demand savings estimates that are reasonably reliable. Therefore, the Department finds acceptable the use of engineering estimates for the purposes of determining non-coincident demand savings estimates for lighting measures installed through the Design 2000 program. However, the Department notes that companies generally are required to perform post-installation measurements of DSM savings to determine savings estimates and directs the Company to perform post-installation measurements to help determine non-coincident demand estimates in future impact evaluations for this program. Similarly, the Department finds acceptable the coincident demand factors based on the results of telephone surveys of

program participants, but directs the Company to use post-installation measurements to determine coincidence factors in future impact evaluations for this program.

The record does not indicate that the Company accounted for savings persistence in the determination of capacity savings estimates for lighting measures installed through the Design 2000 Program. The Department has identified overestimated savings persistence as a source of bias in savings estimates. BECo at 110-111. The record demonstrates that the Company performed a savings persistence study in the EI Program and adjusted the capacity savings estimates for lighting measures installed in that program to reflect the results of the persistence study. The Department finds that, by failing to account for persistence of capacity savings in the Design 2000 Program, the Company has not demonstrated that the lighting capacity savings estimates are sufficiently unbiased. Therefore, the Department does not accept the capacity savings estimates for lighting measures installed through the Design 2000 Program. The Department finds that, because the customers served by the Design 2000 and EI Programs have similar characteristics, applying the results of the EI Program savings persistence study to the capacity savings estimates for the Design 2000 Program should result in less biased savings estimates. Therefore, the Department directs the Company to recalculate the capacity savings estimates for lighting measures installed through the Design 2000 Program during 1991 and 1992 using the savings persistence factor used to calculate capacity savings in the EI Program (i.e., 94 percent). The Company is directed to submit its revised capacity savings estimates in a compliance filing, as set forth in the Order section, below.

The record demonstrates that, for lighting measures installed through the Design 2000

Program, the Company determined energy savings estimates based on non-coincident demand savings estimates and hours-of-use estimates that were based on information reported by program participants. The record demonstrates that the annual hours-of-use estimates that were used to determine lighting energy savings increased from 3,505 hours for 1991 installations to 4,683 hours for 1992 installations (Exh. DPU-1, at A-6, B-6). The record also shows that (1) the hours-of-use estimates used in the calculation of energy savings was substantially greater than the hours-of-use reported in the EI and Small C/I Programs, as determined through end-use metering activities,[38] and (2) post-installation measurements in the EI Program resulted in hours-of-use estimates that were approximately 25 percent less than the standard hours-of-use reported by program participants (id. at IV-17; App. L at 9). Finally, the record indicates that the Company did not account for savings persistence in the determination of energy savings estimates for lighting measures installed through the Design 2000 Program. The Department finds that, by not basing lighting hours-of-use estimates on the results of end-use metering and by failing to account for persistence of energy savings, the Company has not demonstrated that the energy savings estimates are sufficiently unbiased. Therefore, the Department does not accept the energy savings estimates of lighting measures installed through the Design 2000 Program. The Department finds that less biased lighting savings estimates for the Design 2000 Program should result from using (1) the average annual hours-of-lighting-use that was determined by end-use metering in the EI Program and (2) the results of the EI Program savings persistence study. Therefore, the

---

[38] The Company reported average annual hours of use, based on end-use metering, of 3,040 and 3,047 for lighting measures installed through the EI and Small C/I Programs, respectively (Exh. DPU-1, App. L at 9; App. O at 9).

Department directs the Company to recalculate the energy savings estimates for lighting measures installed through the Design 2000 Program during 1991 and 1992 using (1) the average annual hours of lighting use that was determined by end-use metering in the EI Program and (2) the savings persistence factor used to calculate demand savings in the EI Program. The Company is directed to submit its revised energy savings estimates in a compliance filing, as set forth in the Order section, below.

c. Variable Speed Drive Motors

i. Description

The Company reported that variable speed drive motors ("VSDs") were installed in a wide range of applications through the EI and Design 2000 Programs during 1992 (Exh. DPU-1, at III-17).[39] The Company stated that, "[e]ven for a specific type of application, energy and demand savings often depend on installation-specific operating parameters. For these reasons, the analysis used to produce … [savings estimates] reported here relied heavily on engineering models of specific installations, which use equipment operating parameters reported by building operators in telephone interviews, and where available, measured data on specific installations" (id.).

The Company stated that gross energy and coincident demand savings estimates for each VSD installation were developed using one of four distinct methods: (1) pre- and post-installation end-use metering; (2) extrapolations from end-use metered data to other

---

39 VSDs offer opportunities for energy savings in applications where the motor drive speed would otherwise be held constant. Examples of applications are VSDs installed on distribution fans on building HVAC systems, municipal water supply pumps, wastewater treatment pumps and fans, and hydraulic pumps on injection molding machines (Exh. DPU-1, at III-18).

VSDs installed at the same site; (3) engineering models using installation-specific system characteristics and operating parameters; and (4) unit-savings estimates (i.e., KWH and KW saved per installed VSD horsepower ("HP")) derived for each application from one of the three methods listed above (id.).[40] The Company stated that the method used for a given installation depended on the availability of data, and the nature and prevalence of the application (id.). To determine net savings estimates, the Company adjusted the gross savings estimates by free-ridership factors that were developed through the Company's process evaluations (id. at A-15, A-16, A-26, A-27).[41]

The first method by which the Company developed savings estimates consisted of end-use metering of four VSD applications (id. at III-17, 18).[42] The Company stated that savings estimates for VSDs installed on injection molding hydraulic pumps were developed based on the results of two studies. In the first study, the Company developed savings

---

40 Savings estimates from approximately 25 percent of the VSD installations, in terms of installed HP, were developed using methods one and two. Savings from approximately 36 percent of the VSD installations were developed using method three. Savings from approximately 39 percent of the VSD installations were developed using method four (Exh. DPU-1, at III-18).

41 The free-rider adjustment factors were 20 percent for the Design 2000 Program and 12 percent for the EI Program (Exh. DPU-1, at A-15, A-26).

42 The four applications were VSDs installed on injection molding hydraulic pumps, boiler draft fans, boiler feedwater pumps, and industrial process pumps (Exh. DPU-1, at III-18). In terms of installed HP, injection molding hydraulic pumps represented the most prevalent VSD application (approximately 25 percent of total installed HP). The other three applications represented approximately two percent of total installed HP (id.).

estimates for a sample of VSDs installed at one site[43] based on the metering of pre- and post-installation power consumption (id.).[44] The second study involved the metering of a sample of VSDs installed at four facilities. The Company stated that, based on the results of the second study, it developed a model that predicted VSD savings as a function of two operating parameters that are easily obtainable, the rated clamping force of the injection molding machine on which the VSD was installed and the ratio of the machine's idle time to total cycle time (id. at III-17).[45] The Company stated that savings estimates for those VSDs not included in the measurement sample were developed using this model (id.).

The Company also performed metering of VSDs installed on boiler fans, boiler pumps, and one industrial process pump (id.). The Company stated that these measurements were used in conjunction with regression equations to develop models that predict the electrical input power of the fans and pumps as a function of a variable indicating system load for these applications (e.g., boiler steam production), as well as variables for outdoor temperature and pump and fan speed for some of these applications (id., App. H at 4-1, 5-1). The Company stated that these models reliably predicted savings as a function of load within

---

[43] VSDs installed at this site represented greater than 90 percent of the total VSD HP installed on injection molding hydraulic pumps during 1992 (Exh. DPU-1, App. H, Section 2).

[44] The measurement sample included approximately 20 percent of the VSD HP installed at the site and included most of the VSD types installed at the site (Exh. DPU-1, App. H, Section 8).

[45] The Company stated that the model reliably predicted savings for injection machines in which the rated clamping force was less than 500 tons and in which the ratio of idle time to total cycle time was 60 percent or less (Exh. DPU-1, App. H, Section 7, at ii).

the system load regions for which measurements were available (id.).

The second method of developing VSD savings estimates was applied to VSDs installed on injection molding hydraulic pumps at the large installation site described above (id. at III-19). For those VSDs that were not included in the measurement sample, savings estimates were developed by extrapolating the savings estimates produced by the measurements, as expressed by the ratio of savings to pre-installation consumption, to the remainder of the VSDs installed at that site (id., App. H, Section 8).

The third method of developing VSD savings estimates consisted of engineering models that used as input data installation-specific system characteristics and operating parameters as reported by building operators (id. at III-17, 18).[46] The Company stated that it tested the validity of the engineering models by comparing the savings estimates produced by the models for the boiler fan and boiler pump installations described above to the savings estimates produced by the on-site measurements for those same installations (id. at III-20). The Company stated that the savings estimates produced by the engineering models were consistent with the measured savings estimates when the models' input data accurately reflected key operating parameters that were recorded as part of the on-site measurements (id., App. H, Section 6). However, when the input data were based on assumptions regarding these operating parameters, the savings estimates produced by the model exceeded the savings levels produced by the measurements (id.; Exh.DPU-140). The Company stated

---

[46] The engineering model consisted of a series of equations that predicted the pre- and post-installation power consumption of a pump or a fan as a function of the flow or VSD speed (Exh. DPU-125, Attachment C).

that, based on the results of this comparison, it determined that the accuracy of the results of the engineering models depends in large part on the ability of plant operators to supply accurate estimates of two key operating parameters: the flow or speed distribution and the static pressure or pressure offsets, as fractions of the full-load values (Exh. DPU-1, App. H, Section 6, at 1).[47]

In addition, the Company identified a problem regarding the oversizing of motors which, if not accounted for in the engineering models, would lead to overestimates of savings (id., App. H, Section 6, at 11-18).[48] The Company stated that it intended to adjust savings estimates produced by the engineering models for all applications by a motor loading factor of 0.65 (as derived from the Company's motor performance study) to compensate for motor oversizing, but, due to an oversight, it failed to adjust the savings estimates for certain applications (id. at III-20; Exh. DPU-125, at 7). The Company stated that, because of this oversight, the savings estimates for these applications are overstated. In addition, the Company claimed that the 0.65 adjustment factor was incorrectly calculated because it was based on average loading factors rather than peak loading factors, which were not available

---

[47] The Company stated that input data for the engineering models were determined from surveys of program participants that were designed to collect data regarding key operating parameters (Exh. DPU-1, at III-19). In instances where some or all of the operating parameters were unavailable or were determined to be unreliable, the Company used default values describing system characteristics (id., App. H, Section 3).

[48] The Company stated that motor oversizing typically occurs because the nameplate power of a motor typically is larger than the design shaft power (Exh. DPU-125, at 7). Motor oversizing resulted in savings estimates produced by the model that exceeded the measured savings estimates by 34 percent to 148 percent (id.).

at the time of the calculation (Exh. DPU-125, at 7). The Company stated that, because of this miscalculation, savings estimates for those applications that were adjusted by the loading factor were underestimated. The Company stated that it currently is recalculating the adjustment factor using peak loading factors and will submit revised VSD savings estimates as part of its 1992 Second Look savings estimates to be submitted to the Department in June 1994 (id.).

The fourth method of developing savings estimates was applied to VSD installations in which no installation-specific operating data were available (id. at III-20). Savings estimates for these installations were calculated using unit savings estimates that were derived from application-specific results of evaluations using one or more of the three methods described above (id.). For certain applications, which the Company characterized as "unclassified" or "other," unit savings estimates were developed using weighted averages of the unit savings estimates calculated for other applications (id.).

ii. Analysis and Findings

The record demonstrates that the Company developed savings estimates resulting from the installation of VSDs using four methods. The first method used end-use metering to develop savings estimates for four VSD applications. The Department finds that the savings estimates produced by the on-site measurements are sufficiently unbiased and accepts these savings estimates as reported. The record also shows that, for some VSDs installed on injection molding machines, the Company used the results of the end-use metering to develop a model that predicted savings as a function of other operating parameters. The Company then used that model to develop savings estimates for those installations that were not

measured. The Department finds that the savings estimates predicted by the model are sufficiently unbiased and accepts these savings estimates as reported.

The record shows that the second method used to develop savings estimates involved extrapolating the results of on-site measurements for a sample of VSDs installed on injection molding hydraulic pumps to the remainder of the VSDs installed on these pumps at the same site. The Department finds that, because the measurement sample included most of the VSD types installed at the site, the sample was sufficiently representative of the VSDs installed at the site. Therefore, the Department finds that the savings estimates produced by this method are sufficiently unbiased and accepts these savings estimates as reported.

The record shows that the third method used to develop savings estimates consisted of engineering models that used as input data installation-specific operating parameters, as supplied by building operators. The record shows that for several VSD applications where key inputs (e.g., flow rates and static pressure) were measured, the savings estimates predicted by the engineering models corresponded closely to the savings measured by end-use meters. However, the record demonstrates that when these key inputs were based on assumptions rather than measurements, a variety of upward biases appeared in the model results. For example, the record shows that the failure to account for motor oversizing may contribute to the overestimation of VSD savings. The record shows that the Company intended to adjust savings estimates produced by the engineering models for all applications by a factor of 0.65 to compensate for motor oversizing; however, due to an oversight, the Company failed to adjust the savings estimates for certain applications. In addition, the Company claimed that, due to a calculation error, the 0.65 factor is too low. The Company

stated that, for those VSD installation for which savings estimates were developed based on the engineering models, revised estimates will be submitted as part of its 1992 Second Look savings estimates. The Department finds that, because of the misapplication and the miscalculation of the motor loading factor, the savings estimates produced by the engineering models are not sufficiently unbiased. Therefore, the Department does not accept these savings estimates. The Department expects that the Company will submit revised 1991 and 1992 savings estimates for these VSD applications in its June 1994 filing.[49] The Department will review the revised savings estimates at that time.

The record shows that the fourth method used to develop savings estimates involved the application of unit savings estimates (i.e., savings per installed HP of VSD), derived using the three methods described above, to installations in which no installation-specific data were available. For those unit savings estimates that were calculated based on measured data, the Department finds that, because the measurements were found to be sufficiently unbiased, the unit savings estimates that were based on the measurements are sufficiently unbiased and accepts these savings estimates. For those unit savings estimates that were calculated based on the results of engineering models, the Department finds that, because the savings estimates produced by the engineering models were found to be biased, the unit savings estimates that were based on the engineering models are similarly biased. Therefore, the Department does not accept these savings estimates. The Department expects that the

---

[49] The Department expects the Company to take into consideration all of the factors that were identified as leading to overestimated savings estimates in recalculating the savings estimates produced by the engineering models.

Company will submit revised unit savings estimates for 1991 and 1992 VSD installations that reflect the revised savings estimates produced by the engineering models in its June 1994 filing. The Department will review the revised unit savings estimates at that time.

The Department notes that 1992 VSD savings estimates represented a significant percentage of total savings for the EI and Design 2000 Programs.[50] As such, the Department expects that, in the future, VSD savings estimates will be developed using on-site measurements to a greater extent than in the present filing, when it is cost-effective to do so. In particular, the Department expects the Company to take appropriate steps, in future impact evaluations, to ensure that, when VSD savings estimates are to be determined based on engineering models, the key data inputs to these models are based on on-site measurements (e.g., by requiring that participants maintain flow logs and/or similar operational data).

The record shows that the Company has not yet studied the persistence of VSD savings. The Department expects the Company to study the persistence of savings from VSDs in future impact evaluations. Finally, the record shows that the Company did not report the precision of the VSD savings estimates. The Department expects the Company to report the statistical precision of the measured VSD savings estimates in future impact evaluations.

---

[50] For the EI Program, 1992 VSD savings estimates represented approximately 15 percent of total savings. For the Design Program, 1992 VSD savings estimates represented approximately 31 percent of total savings (see Table 4 below).

d. Other Motors

i. Description

To develop lifetime energy and demand savings estimates for motors installed through the EI and Design 2000 Programs, the Company relied on a study performed jointly with Northeast Utilities and Boston Edison Company entitled "1993 Motor Baseline Study" ("Baseline Study") (Exh. DPU-1, at IV-28). The purpose of the Baseline Study was to develop an understanding of the efficiency of motors sold by motor manufacturers and distributors in New England (id.). Using the Baseline Study, the Company developed an estimate of baseline motor efficiency for both standard and high efficiency motors.[51] Based on the "spread" between high efficiency and standard motors and the number of motors installed, the Company developed its engineering estimates of energy and demand savings for each high efficiency motor available through the Company's programs (id.). Combined installations in the EI Program and the Design 2000 Program totalled 2,922 motors in 1992 (id. at IV-29).

Following the development of its engineering estimates, the Company performed a second study to measure the actual performance of motors installed through the EI and Design 2000 Programs (id.). The second study, entitled "Motor Performance Study" ("Performance Study"), measured the actual performance of 193 high-efficiency motors installed in 30 facilities (id. at IV-28). The Performance Study was conducted by installing meters that measured the KW consumption and coincidence factor for each motor, over a

---

[51] While the study was regional, it included a specific section for MECo's service territory.

24-hour study period (id. at 29). The results of the Performance Study indicated that the actual demand savings from each motor were, on average, 64 percent of engineering estimates of savings, representing the motors' realization rate (id. at IV-29).

Energy savings estimates then were calculated using four factors. First, based on the performance study results, the Company assumed that its demand savings per motor equalled 64 percent of engineering estimates. Second, the Company determined hours-of-use estimates using a building operation survey (id. at A-25, App. F).[52] Third, the Company determined free riders through a study that revealed that free riders accounted for 12 percent of installations for the EI Program and 24 percent for the Design 2000 Program (id. at A-11, A-25).[53] Fourth, the Company based its estimate of persistence on the assumption that each motor had a 20-year lifetime and, thus, would provide energy savings for 20 years (id. at A-11).[54] Using the above factors as inputs, final lifetime energy savings estimates for motors installed in 1992 were calculated by the Company to be 104,365 MWH (id. at IV-29).

Demand savings were calculated using four factors. First, engineering estimates of

---

[52] For the Design 2000 Program, the Company based its hours-of-use estimates on the results of a random sample telephone survey of 42 participants from a possible 71 participants who installed high efficiency motors (Exh. DPU-1, App. F at 4). Based on the results of the survey, the Company developed estimates of 5,373 hours-of-use per motor per year (id. at A-13, A-14). For the EI Program, the Company based its hours-of-use estimate on a similar survey of 42 participants from a possible 198 participants (id. App. F at 3). Based on the results of the survey, the Company developed estimates of 5,158 hours-of-use per motor per year (id. at A-25).

[53] Free riders were determined by the Company using a customer survey of EI and Design 2000 Program participants (Exh. DPU-1, at App. J, App. D).

[54] The Company stated that its 20-year motor lifetime estimates were based on estimates contained in their 1992 Compliance Filing (Exh. DPU-1, at A-13).

demand savings were multiplied by the 64 percent realization rate from the Performance Study. Second, the Company subtracted the effects of free riders from its savings estimates (id. at A-11, A-25).[55] Third, the Company adjusted its estimates to reflect coincidence factors of 85 percent for summer and 73 percent for winter (id. at IV-28). The Company thus determined that final demand savings for motors installed in 1992 were 864 KW in winter and 743 KW in summer (id. at IV-29).

In addition to using the results of the 1993 Motor Baseline Study and its Performance Study to determine savings achieved in 1992, the Company used the results of these studies to calculate its Second Look estimates of savings achieved in 1991 (id. at XIII-9).[56] The Company indicated that Second Look energy and demand estimates were 11 percent lower than First Look estimates for the EI Program and 6 percent lower than First Look estimates for the Design 2000 Program (id.). Therefore, the Company reduced its 1991 savings estimates to reflect its Second Look calculations.[57]

---

55 The Company therefore reduced its engineering estimates by 52 percent for the EI Program to account for the combined effects of a 64 percent realization rate and a 12 percent free rider estimate (Exh. DPU-1, at IV-28, IV-29, A-11, A-25). For the Design 2000 Program, the Company reduced its engineering estimates by 60 percent to account for the combined effects of the 64 percent realization rate and a 24 percent free rider estimate (id.).

56 Since the savings were based on 1991 participants, the Company continued to use its demand savings and hours-of-use estimates developed based on the 1991 installations (Exh. DPU-1, at XIII-9).

57 Lifetime savings estimates from the 1991 program installations were 86,817 MWH and 13,236 KW (Exh. DPU-1, at XIII-9).

ii. Analysis and Findings

The record demonstrates that the Company has based its savings estimates on the after-the-fact measurements of motor performance, hours-of-use and free riders. The Department finds that the Company, through the Baseline Study, end-use metering, and free-ridership surveys, took reasonable steps to ensure that the savings estimates are sufficiently unbiased. Therefore, the Department accepts the 1991 and 1992 motor savings estimates as reported.

The Department notes, however, that, in calculating lifetime savings estimates for the installed motors, the Company did not include an adjustment to account for persistence of savings. In MECo at 110-111, the Department directed the Company to perform follow-up surveys at appropriate intervals to estimate persistence of savings and to develop savings-decay curves for all major ECMs. In addition, the Department has found it critical to measure DSM equipment's useful life and persistence of savings over time. ComElectric at 86. The Department also has found it is critical that a measure's life be updated over time to track actual life as closely as possible. WMECo at 136. Therefore, the Department expects the Company to include motor savings persistence information in future impact evaluations.

e. HVAC and Building Shell Measures

i. Description

The Company reported that HVAC and building shell measures were installed through the EI and Design 2000 Programs during 1992 in a variety of applications (Exh. DPU-1, at A-9, A-10, A-22, A-23). For HVAC measures, the majority of savings resulted from the

installation of building energy management ("EM") systems and thermal storage systems.[58] For building shell measures, the majority of savings resulted from the installation of window film (id.).

The Company stated that savings for HVAC and building shell measures vary greatly depending on the application (id. at III-13). The Company stated that, for each application except thermal storage systems, site visits were conducted at a sample of installations to collect operational information that served as input data to an energy simulation computer model that produced gross energy and demand savings estimates for those installations (id.).[59] For each application, the savings estimates for installations included in the sample were summed and normalized to units (e.g., KWH saved per square foot of installed insulation). The application-specific unit savings estimates were applied to those installations that were not part of the sample (id.).

The Company stated that gross savings estimates for thermal storage systems were developed based on a combination of a billing analysis and end-use metered data (id. at III-14).[60] The Company stated that, based on the results of these measurement activities, it

---

58 Thermal storage systems use off-peak electricity to chill water or to make ice from which cool air or water is extracted for air conditioning during times of peak electric demand (Exh. DPU-1, App. T at 1).

59 The Company reported that the sites were chosen to represent a substantial fraction of the projected savings, and covered a broad range of installation sizes, facility sizes, and facility types (Exh. DPU-1, at III-13).

60 The Company performed a billing analysis at four thermal storage sites and used end-use metering at three sites to estimate the change in power consumption (i.e., load shift) on an hourly basis for the 13 days during the summer of 1992 with at least six or more cooling degree-days (a cooling degree-day is computed by subtracting a

(continued…)

calculated a realization rate for demand savings of 62 percent. The Company stated that it adjusted demand savings estimates for all thermal storage systems installed during 1991 and 1992 by a factor of 62 percent (id., at A-9, B-11).

Net savings estimates were developed by adjusting the gross savings estimates for all HVAC and building shell measures to reflect free-ridership factors that were developed based on the results of the Company's process evaluations (id. at A-9, A-22, B-12, B-23).

As part of its savings persistence study for the EI and Design 2000 Programs, the Company assessed the persistence of savings associated with the installation of EM systems, economizers installed on rooftop air conditioners,[61] and window film (id. at III-22 through III-25). For EM systems, the Company conducted on-site surveys at 17 installation sites in order to (1) physically confirm whether the EM system was in place and operational, (2) review control points and strategies[62] and (3) confirm that controlled equipment was operating as intended (id., App. M, Section 2, at 15-17). The Company stated that the surveys showed that some EM system control points no longer functioned properly and that some control strategies were inappropriately designed (id.). In addition, the surveys identified the following problems associated with the installations: improper installations; changes in facility loads or operations; mechanical failures of hardware; operator overrides;

---

[60](…continued)
reference temperature, such as 70°F, from the average of the day's high and low temperatures) (Exh. DPU-1, App. T at 1-2). .

[61] Rooftop air conditioning economizers utilize the coolness in the outdoor air to decrease the energy requirements of the air conditioning units.

[62] EM systems rely on control points and strategies to control operation of HVAC equipment (Exh. DPU-1, App. M, Section 2, at 14-15).

errors in original savings calculations; and a baseline assumption of no nighttime temperature setback (id.; Exhs. DPU-51; DPU-64; DPU-66).

For the six EM installations that were retrofit projects, the Company compared the estimated post-installation electricity consumption, based on data collected during the on-site surveys, to the estimated pre-installation electricity consumption, based on data that reflected the pre-installation HVAC control systems (Exh. DPU-1, App. M, Section 2). The Company stated that, based on the results of the surveys, it determined EM savings persistence factors of 74 percent for energy savings and 0 percent for capacity savings (id.). The Company stated that, for EM systems installed as part of new construction/renovation projects, it did not attempt to define a pre-installation consumption baseline (id., App. M, Section 2, at 16). The persistence study stated that, although all of the control points for these installations were in place and operating, "[f]or the most part the EM … [systems were] executing strategies that are either required by [building] Code or would likely have been installed … via another system like a time clock" (id.). The Company adjusted energy and capacity savings estimates for EM systems installed during 1991 to reflect the savings persistence factors (id. at B-11, B-12, B-22, B-23). However, the Company stated that it did not adjust the savings estimates for EM systems installed during 1992 to reflect the savings persistence factors because the 1992 savings estimates were based on site-specific analyses that implicitly accounted for the problems identified by the persistence survey (id. at IV-32; Exhs. DPU-51; DPU-64; DPU-66).

To assess the persistence of savings of economizers installed on rooftop air conditioning units ("RTUs"), the Company performed site visits to 25 facilities in which 53

RTU economizers, with a combined cooling capacity of 524 tons per hour,[63] were installed during 1990 and 1991 (Exh. DPU-1, App. M, Section 2, at 5). Each RTU economizer was physically inspected to confirm the presence of all critical system components (id., App. M, Section 2, at 6).[64] The Company stated that the study found that only 44 percent (by tons of cooling capacity) of the reported RTU economizers were in place and operational (id., App. M, Section 2, at 7). The Company stated that, based on the results of the persistence study, it multiplied the energy savings estimates for RTU economizers installed during 1991 and 1992 by a factor of 44 percent (id. at IV-32).

To assess the persistence of window film savings, the Company examined 26 window film installations, comprising 28 percent of the square feet installed during 1990 and 1991 (id. at IV-31).[65] The Company stated that, based on the results of the site examinations, it developed savings persistence factors of 78 percent for energy savings and 48 percent for summer demand savings (id. at IV-33).[66] The Company applied these factors to savings estimates for window film installed during 1991 (id.). However, the Company stated that, because savings estimates for window film installed during 1992 were based on site-specific

---

63 A ton of cooling capacity is the energy required to freeze one ton of water.

64 The Company stated that, because site visits were conducted during winter months, observation of the economizers under cooling conditions and calibration of operating parameters were not possible (Exh. DPU-1, App. M, Section 2, at 6).

65 Window film accounted for 79 percent of the Company's claimed savings from building shell ECMs (Exh. DPU-1, at A-10, A-23, B-12, B-23).

66 The Company stated that the reduced savings estimates were primarily due to north-facing windows and the effects of external building overhangs that had not been accounted for sufficiently in the original engineering estimates (Exh. DPU-1, at IV-33).

analyses which implicitly accounted for the problems identified by the site examinations (i.e., overhangs and north-facing windows), it did not apply the persistence factors to the 1992 savings estimates (id.).

ii. Analysis and Findings

The record shows that, for HVAC and building shell applications installed through the EI and Design 2000 Programs (with the exception of thermal storage systems), gross savings estimates were developed based on computer simulation models that used data collected from on-site visits at a sample of installations to calculate application-specific unit savings estimates. The record shows that the Company adjusted the savings estimates to account for coincidence with system peak power demand and free riders.

The Department finds that, because the computer model used to develop the savings estimates for the sample of installations visited was able to predict savings for complex installations and used input data that was site-specific, the unit savings estimates produced by the model are sufficiently unbiased. The Department also finds that, because the sample of installations visited accounted for a substantial amount of the projected savings from HVAC and building shell installations, and covered a broad range of applications, the sample is sufficiently representative of the population of HVAC and building shell measures installed during 1992. Therefore, the Department finds that, with the exception of EM system and RTU economizer installations, as discussed below, the savings estimates produced by applying the unit savings estimates to the population of HVAC and building shell measures are sufficiently unbiased.

The record shows that the Company used billing analysis and end-use metering to

estimate the savings from thermal storage systems. The Department finds the thermal storage study to be thorough and finds that the savings estimates are sufficiently unbiased.

The record shows that the Company assessed the persistence of savings resulting from the installation of EM systems installed through the EI and Design 2000 Programs during 1991, but did not adjust the savings estimates for EM systems installed during 1992 to reflect the results of the persistence study. The record also shows that the persistence study reported that, for new construction/renovation installations, the EM strategies would have been employed in the absence of the programs. The Department finds that certain of the problems cited by the Company as reasons for the decrease in savings from 1991 installations (e.g., inappropriate control strategy designs, incorrect savings calculations) are within the control of the Company, and thus, may have been addressed during the determination of the 1992 savings estimates. However, the Department finds that other problems cited by the Company as reasons for the decrease in savings from 1991 installations (e.g., improper installations, changes in facility loads or operations, mechanical failures of hardware, and operator overrides) lie outside the Company's control and apply equally to 1992 installations as to 1991 installations. The Department finds that, because the energy and capacity savings estimates for EM systems installed during 1992 were not adjusted to reflect the results of the persistence study, these savings estimates are not sufficiently unbiased. Therefore, the Department does not accept these savings estimates.

For retrofit EM installations, the Department finds that, because some problems identified in the persistence study are within the control of the Company, and other problems are outside the Company's control, the appropriate persistence adjustment factors are the

averages of the adjustment factors identified in the persistence study (i.e., 74 percent for energy savings and 0 percent for capacity savings) and the 1992 adjustment factors used by the Company (i.e., 100 percent for both energy and capacity savings). Therefore, the Company is directed to multiply the energy savings estimates for 1992 retrofit EM installations by a factor of 87 percent and the capacity savings estimates for 1992 retrofit EM installations by a factor of 50 percent. The Company is directed to submit the revised savings estimates in a compliance filing, as set forth in the Order section, below.

For new construction/renovation EM installations, the Department finds, because the 1992 savings estimates reported by the Company do not reflect the persistence study's finding that the EM strategies would have been employed in the absence of the programs, the savings estimates are not sufficiently unbiased. Therefore, the Department does not accept the savings estimates for 1992 new construction/renovation EM installations. The Department finds that the Company has not demonstrated that the 1992 EM strategies used in 1992 new construction/renovation EM installations would not have been employed in the absence of the programs. Therefore, the Department directs the Company to multiply its energy and capacity savings estimates for 1992 new construction/renovation EM installations by the adjustment factors identified in the persistence study (i.e., 74 percent for energy savings and 0 percent for capacity savings). The Company is directed to submit the revised savings estimates in a compliance filing, as set forth in the Order section, below.

The record shows that, based on the results of its persistence study, the Company adjusted energy savings estimates for RTU economizers by a factor of 44 percent. The record also shows that, because the site visits did not take place during the cooling season,

the Company could not monitor the operation of the economizers under cooling conditions. For the purposes of this proceeding, the Department accepts the savings persistence factor reported by the Company. However, in future impact evaluations, the Department expects the Company to conduct its on-site measurement activities of RTU economizers during the cooling season, so that the operation of the economizers can be tested under cooling conditions. The Department finds that the energy savings estimates for RTU economizers, which were based on the persistence factor, are sufficiently unbiased. However, the Department finds that, because the capacity savings estimates for RTU economizers were not adjusted to reflect the results of the persistence study, the capacity savings estimates are not sufficiently unbiased. Therefore, the Department does not accept the capacity savings estimates for RTU economizers. The Department finds that the persistence factor produced by the persistence study applies equally to energy and capacity savings estimates. Therefore, the Department directs the Company to adjust the 1991 and 1992 capacity savings estimates for RTU economizers by the same persistence factor applied to energy savings estimates (i.e., 44 percent). The Company is directed to submit the revised capacity savings estimates in a compliance filing, as set forth in the Order section, below.

The record shows, for window film, the Company analyzed site-specific factors that might influence the performance of the window films. The record shows that the Company identified several factors that accounted for the difference between its original 1991 savings estimates for window film and its revised 1991 estimates. The Company stated that it accounted for these same factors in its original 1992 window film savings estimates. The Department finds that the Company appropriately incorporated the results of its window film

analysis into its 1992 estimates, in such a way that the savings estimates are sufficiently unbiased. Therefore, the Department accepts the window film savings estimates as reported.

The Company is expected, in future impact evaluations, to increase the level of savings estimates for HVAC and building shell measures that are developed from direct measurements. In addition, the Company is expected to study the persistence of savings for other types of HVAC and building shell measures, in addition to those which it recently examined, as well as to revisit at appropriate future dates the persistence of those measures already examined. Finally, the record shows that the Company did not report the precision associated with the savings estimates for HVAC and building shell measures. The Department expects the Company to include statistical precision data associated with its measured savings estimates in future impact evaluations.

f. Custom Measures

i. Description

The Company reported that 44 custom measures were installed through the Design 2000 Program, and 20 custom measures were installed through the EI Program during 1992 (Exh. DPU-1, at III-21, IV-30).[67] The largest custom measures types installed, in terms of savings achieved, were building energy management ("EM") systems, refrigerant pumps, and

---

[67] The Company stated that the installations addressed under "custom measures" required installation-specific (i.e., custom) operational data to calculate savings estimates and rebate levels. Thus, these installations were not included in the "prescriptive" components (e.g., HVAC measures) of the EI and Design 2000 Programs (Exh. DPU-1, at III-21).

lighting controls (id., at A-10, A-23).[68]

The Company stated that gross energy and coincident demand savings estimates for the custom installations were developed based on engineering calculations that used as input data operational information that was provided by program participants on their project applications (id. at III-21). The Company stated that the operational data were certified by a registered Professional Engineer, then reviewed for accuracy, and adjusted as necessary, by Company personnel (id.). To determine net savings estimates, the Company adjusted the gross savings estimates by free-ridership factors that were developed through the Company's process evaluations (id. at A-10, A-23).[69]

The Company stated that, for seven custom installations for which the expected savings levels were "large," on-site surveys were conducted to verify the operational data included with the project applications (id. at III-21; Exh. DPU-155).[70] The Company reported that the verified operating hours at these installations differed significantly from the

---

68 The Company reported that approximately 22 percent of the total energy savings from custom measures resulted from the installation of EM systems, 13 percent from refrigerant pumps, and 6 percent from lighting controls (Exh. DPU-1, at A-10, A-23, B-23).

69 For 1992, the free-ridership adjustment factors for all measures except lighting controls were 25 percent for Design 2000 installations and 12 percent for EI installations (Exh. DPU-1, at A-10, A-23). For lighting controls, the free-ridership adjustment factors were 26 percent for Design 2000 installations and 4 percent for EI installations (id.).

70 Collectively, these seven custom measure installations accounted for approximately 13 percent of the total annual energy savings from custom measures installed in the EI and Design 2000 Programs during 1992 (Exh. DPU-155; Exh. DPU-1, at A-10, A-23). None of the larger custom measure types was included in the survey (Exh. DPU-155).

hours previously estimated, but not in a consistent pattern (Exh. DPU-155). The Company stated that, based on the results of the on-site surveys, savings estimates for three projects were revised from the initial estimates. The Company stated that, although the on-site surveys resulted in an overall increase to the initial level of savings estimates for the seven projects,[71] it did not revise the savings estimates of the entire population of custom measure installations to reflect this increase because the sample of installations surveyed was too small (id.).

As part of its savings persistence study for the EI and Design 2000 Programs, the Company conducted on-site surveys of EM systems installed in 17 facilities during 1991 to assess the persistence of savings resulting from such installations (Exh. DPU-1, App. M, Section 2, at 14-24).[72] Based on the results of the surveys, the Company reduced energy savings estimates for EM systems installed during 1991 by 26 percent and reduced capacity savings estimates for the same installations by 100 percent (id. at B-22, B-23). The Company stated that it did not revise the savings estimates for EM systems installed during 1992 to reflect the results of the persistence survey because the 1992 savings estimates were based on site-specific analyses that implicitly accounted for the problems identified by the persistence survey (id. at IV-32; Exhs. DPU-51; DPU-64; DPU-66).

---

[71] Total energy savings estimates for the seven installations increased by 9 percent over the initial estimates. Capacity savings estimates increased by 62 percent in the winter and decreased by nine percent in the summer (Exh. DPU-155).

[72] For a description of the on-site surveys and the results of the surveys, see pages 44 and 45, above.

ii. Analysis and Findings

The record shows that savings estimates for seven of the largest custom measure installations, representing approximately 13 percent of the total savings resulting from the installation of custom measures, were based on the results of on-site surveys that verified customer-supplied operational data. The savings estimates for the remainder of the 1992 custom measure installations were based on operational data that were supplied by program participants with their project applications.

The Department finds that, because the savings estimates for the seven large projects were based on the results of on-site verification surveys, the savings estimates for those projects are sufficiently unbiased. In addition, the Department finds that, because of the small sample of projects surveyed and the lack of a consistent relationship between expected and verified operating hours, the Company acted appropriately in not applying the results of the on-site surveys to the total population of custom measures installed during 1992. The Department finds that, with the exception of custom EM system and custom lighting control installations, as discussed below, the savings estimates for custom measure installations are sufficiently unbiased.

The record shows that, as part of the EI and Design 2000 persistence study, the Company assessed the persistence of savings resulting from the installation of EM systems. The record shows that the Company did not adjust the savings estimates for custom EM systems installed during 1992 to reflect the results of the persistence study. In Section IV.B.1.e, above, the Department directed the Company to revise its energy and capacity savings estimates for non-custom 1992 EM installations to reflect the results of the

persistence study. See pages 48 through 49, above. The Department finds that the results of the persistence study apply equally to custom and non-custom EM installations. Therefore, the Department finds that the savings estimates for custom EM systems installed during 1992 are not sufficiently unbiased and does not accept those savings estimates. The Company is directed to revise its savings estimates for custom installations in the following manner. For 1992 retrofit installations, the Company is directed to multiply the energy savings estimates by a factor of 87 percent and the capacity savings estimates by a factor of 50 percent. For new construction/renovation installations, the Company is directed to multiply the energy savings estimates by a factor of 74 percent and the capacity savings estimates by a factor of 0 percent. The Company is directed to submit the revised savings estimates in a compliance filing, as set forth in the Order section, below.

The record shows that, as part of the EI and Design 2000 persistence study, the Company assessed the persistence of savings resulting from the installation of lighting control measures. The record shows that the Company adjusted the capacity savings estimates for non-custom lighting control measures installed through the EI Program during 1991 and 1992 to reflect the results of the persistence study, but did not adjust the savings estimates for custom lighting control measures to reflect the results of the persistence study. The Department finds that the savings persistence factor that was applied to non-custom lighting control measures installed through the EI Program is appropriately applied to custom lighting control measures installed through the EI and Design 2000 Programs.[73] Therefore, the

---

[73] The Department notes that the Company used the same process evaluation study to

(continued…)

Department finds that the savings estimates for custom lighting control measures are not sufficiently unbiased and does not accept the savings estimates. The Company is directed to adjust the energy and capacity savings estimates of custom lighting control measures installed during 1991 and 1992 using the savings persistence factor that was applied to non-custom lighting control measures (i.e., 94 percent). The Company is directed to submit the revised savings estimates in a compliance filing, as set forth in the Order section, below.

The Department recognizes that, for a program that provides for the installation of a wide range of custom measures, it is difficult to develop savings estimates using measured operational data for each of the installations. However, the Department expects the Company to increase its measurement activities in future impact evaluations of custom measures. The Department also expects the Company to increase its savings persistence assessment activities for these measures. Finally, the record shows that the Company did not report the precision associated with the savings estimates for custom measures. The Department expects the Company to include statistical precision data associated with its measured savings estimates in future impact evaluations.

---

[73](…continued)

develop free-ridership adjustment factors for both custom and non-custom lighting control measures installed in the EI and Design 2000 Programs (Exh. DPU-1, at A-5, A-10, A-18, A-23). The free-ridership factors for each program were identical for non-custom and custom lighting control measures (id.).

g. Process and Refrigeration Measures

i. Description

The Company stated that process measures installed through the Design 2000 and EI Programs during 1992 consisted of food service refrigeration measures, insulating blankets for injection molding machines, and insulation of bench top vulcanizers for the jewelry industry (Exh. DPU-1, at III-21; IV-29). The Company stated that engineering estimates of the gross energy and demand savings for these measures were developed by the Demand Management Institute; no installation-specific analysis was performed to determine savings estimates for these measures (id.). The Company stated that gross savings estimates for refrigeration measures were based on unit savings estimates developed by Xenergy and Foster Miller; no installation-specific analysis was performed to determine savings estimates for these measures (id. at III-22). All gross savings estimates were adjusted by a free-ridership factor developed through the Company's process evaluations (id., at A-7, A-22, B-23).

As part of its savings persistence study for the EI and Design 2000 Programs, the Company conducted on-site surveys of insulating blankets installed on a sample of injection molding machines at ten sites during 1991 to assess the persistence of savings resulting from such installations (id., App. M, Section 2, at 14-24). The Company stated that, based on the results of the persistence study, it applied a persistence factor of 87 percent to savings estimates for insulating blankets installed during 1991 and 1992 (id., at A-7, A-20, B-22).

ii. Analysis and Findings

The record shows that the gross savings estimates for process and refrigeration

measures were based on engineering estimates that were not adjusted to reflect installation-specific operational data. For the purposes of this proceeding, the Department accepts the savings estimates for these measures. However, the Department expects the Company, to the degree possible and when cost-effective, to develop savings estimates based on actual measurements in future impact evaluations.

The record shows that the Company adjusted savings estimates for insulation installed on injection molding machines by a factor of 87 percent to reflect the results of its savings persistence study. The Department finds that the Company acted appropriately in conducting post-installation measurements for insulation installed on injection molding machines, the measure application that provided the majority of the savings from process and refrigeration measures. The Department finds that the savings estimates for insulation installed on injection molding machines are sufficiently unbiased and accepts the savings estimates as submitted. The Department expects the Company, in future impact evaluations, to increase its savings persistence assessment activities for process and refrigeration measures.

Finally, the record shows that the Company did not report the precision associated with the savings estimates for process and refrigeration measures. The Department expects the Company to include statistical precision data associated with its measured savings estimates in future impact evaluations.

2. Small Commercial and Industrial Program

a. Description

The Company began implementation of the Small Commercial and Industrial ("Small C/I") Program in 1990. The program targets general use customers whose monthly demand

does not exceed 50 KW or whose annual energy consumption does not exceed 150,000 KWH (Exh. DPU-1, at V-1). During 1992, the program focused almost exclusively on energy-efficient lighting equipment, with only one percent of program savings resulting from the installation of non-lighting ECMs (id. at V-14).[74] The Company provided DSM services through this program to 2,735 customers during 1992 (id.). It reported First Look annual energy savings estimates of 14,357 MWH and annual capacity savings estimates of 7,026 KW for ECMs installed during 1992. In addition, the Company reported Second Look annual energy savings estimates of 9,892 MWH and annual capacity savings estimates of 4,982 KW for ECMs installed during 1991 (id. at B-1).

The Company's 1992 impact evaluation for the Small C&I Program consisted of five major components: (1) post-installation engineering estimates of energy and demand savings based on the number of ECMs installed; (2) a billing analysis of program participants; (3) short-term end-use metering; (4) on-site surveys to assess savings persistence; and (5) telephone surveys to develop free-ridership estimates (id. at V-2).

As a first step in determining savings estimates for this program, the Company developed post-installation engineering estimates of energy and demand savings based on (1) the number of ECMs installed, (2) wattage data supplied by lighting manufacturers, (3) hours-of-use data provided by program participants, and (4) free-rider and coincident

---

[74] Lighting technologies offered in 1992 included energy-efficient fluorescent lamps, ballasts, and fixtures; specular reflectors; hard-wired compact fluorescent systems; screw-in compact fluorescents; interior and exterior high-intensity discharge systems; reduced-wattage incandescent lamps; occupancy sensors; and time clocks and photocells for outdoor lighting (Exh. DPU-1, at V-1). Non-lighting measures included programmable thermostats and electric water heater tank wraps (id.).

demand adjustment factors developed from information collected through the Company's 1991 M&E activities (id. at V-3).

To determine energy savings estimates, the Company performed a billing analysis that compared pre- and post-installation energy usage data of a group of 889 customers who participated in the program during 1991 (the "participant group") with pre- and post-installation energy usage of a group of 1,528 randomly-selected non-participants (the "comparison group") (id.).[75] The Company stated that, in an attempt to ensure that the members of the comparison group had similar characteristics to the members of the participant group, the members of both groups were stratified by pre-installation energy consumption and by customer facility type (id.). The billing analysis resulted in energy savings estimates for the sample of participants included in the participant group that were 49 percent of the engineering estimates for that group (id. at V-5).[76] The Company stated that, to determine the net energy savings for this program, it applied an adjustment factor of 49 percent to the engineering estimates of energy savings for all lighting measures installed during the 1992 program year (id. at V-5, 6).[77] The Company stated that it did not adjust

---

75 The pre-installation period was defined as January 1, 1990 through December 31, 1990. The post-installation period was defined as January 1, 1992 through December 31, 1992 (Exh. DPU-1, at V-3).

76 The billing analysis resulted in energy savings estimates of 6,873 annual KWH per participant group member, as compared to the engineering estimates of 14,201 annual KWH saved per participant group member (Exh. DPU-1, at V-5). The Company stated that the precision level of the savings estimates was $\pm$41 percent, at the 90 percent confidence level (id., Appendix C).

77 The Company stated that, because non-lighting measures were not available through this program until late in 1991, it did not apply the results of the billing analysis to

(continued…)

the energy savings estimates to account for savings persistence or free riders, since the effect of these factors would be accounted for in the billing analysis (id. at V-12).

The Company noted that the 49 percent realization rate indicated by the 1992 billing analysis was significantly lower than the 78 percent realization rate indicated by a billing analysis performed in 1991 (id. at V-6). The Company claimed that the decrease in the 1992 realization rate was attributable more to increases in the energy usage of the comparison group members than to a reduction in the savings levels achieved by the program.[78] The Company stated that, in order to develop more accurate energy savings estimates for this program in the future, a more sophisticated analytical approach may be required (id.). The Company additionally noted that the energy savings estimates resulting from the 1992 billing analysis were significantly lower than the savings estimates resulting from its end-use metering activities, described below (id. at V-8).[79] The Company stated that it chose to use the "more conservative" estimates reported by the 1992 billing analysis because of the greater sample size used in that analysis (id.).

---

[77](…continued)
the engineering estimates of energy savings for non-lighting measures installed during 1992 (Exh. DPU-1, at V-6).

[78] To support this claim, the Company noted that the energy usage of the average comparison group member in the 1992 billing analysis decreased by 0.2 percent from the pre- to the post-installation period, whereas, over the same period in the 1991 billing analysis, the energy usage of the average comparison group member increased by 1.1 percent (Exh. DPU-1, at V-6). The Company stated that, in contrast, the ratio of energy savings to pre-installation energy usage for the sample of program participants included in the participant group was relatively constant between the 1991 and 1992 billing analyses (id.).

[79] The Company stated that the end-use metering resulted in energy savings estimates that were 90.5 percent of the engineering estimates (Exh. DPU-1, at V-8).

The Company determined capacity savings for the Small C/I program based on the results of an end-use metering study, adjusted for savings persistence and free riders. The Company stated that it metered a representative sample of lighting circuits at the sites of 40 program participants (id. at V-6).[80] The circuits typically were metered for two-week periods both before and after installation to collect load profile and hours-of-use data (id.). The end-use metering resulted in coincident demand savings estimates that were 85.0 percent of the engineering estimates for savings achieved during the summer and 73.2 percent of the engineering estimates for savings achieved during the winter (id. at V-7).[81]

The Company stated that it determined the gross capacity savings for this program in two steps. First, it applied the coincident demand adjustment factors to the engineering estimates of demand savings for all interior lighting measures installed during 1992 (id.).[82] Second, it adjusted the coincident demand savings estimates to account for savings persistence (id.). The Company stated that, to assess the persistence of demand savings, it conducted surveys at the sites of 200 customers who had participated in the program during

---

80 The Company stated that, in terms of average energy savings, average demand savings, and average hours of use of the installed lighting measures, statistical analysis demonstrated that the sampled program participants were representative of the total population of program participants (Exh. DPU-1, Appendix O at 8).

81 The Company reported the following precisions for the savings estimates at the 90 percent confidence level: (1) $\pm$10.7 percent for the coincident summer demand savings; and (2) $\pm$18.1 percent for the coincident winter demand savings (Exh. DPU-1, at V-7).

82 The Company stated that, because the pattern of use for exterior lighting and lighting control measures is significantly different from interior lighting measures, it used coincident peak adjustment factors for these measures that were developed from its 1992 Commercial and Industrial Program Equipment Operating Survey (Exh. DPU-1, at V-7).

1990 and 1991 to determine how many of the installed ECMs remained in place and to identify the reason for any equipment replacements (id. at V-8). The Company stated that, based on the results of the on-site surveys, it calculated a savings persistence rate of 92 percent for measures installed during 1990, and 94 percent for measures installed during 1991 (id.). The Company stated that, because the results from the 1990 sites better reflect savings persistence, it adjusted the capacity savings estimates by the 1990 persistence rate of 92 percent (id. at V-9).

Finally, the Company stated that it conducted a telephone survey of 501 customers who participated in the program during 1992 to develop free-ridership estimates for each type of ECM category (id. at V-9, 11). The Company stated that, to determine the net capacity savings for this program, it adjusted the gross capacity savings estimates to account for free riders (id. at 12).

b. Analysis and Findings

The record demonstrates that, in developing energy savings estimates for the Small C/I Program, the Company assessed the results of two measurement techniques: (1) a billing analysis of 889 program participants and 1,528 non-participants, in which both groups were stratified by energy usage and facility type; and (2) end-use metering of lighting circuits at the sites of 40 program participants. The record demonstrates that the Company selected the energy savings estimates resulting from the billing analysis because of the significantly greater sample size used in that analysis, even though the savings estimates from the end-use metering activities were measured to a higher level of precision. The Department previously has found that a billing analysis of program participants that employs a comparison group

"can provide accurate estimates of energy savings at modest expense, while controlling for free riders …." MECo at 103. The Department has identified the poor selection of samples used in savings measurement analyses as a source of bias in the savings estimates produced by the analyses. WMECo at 138. In this proceeding, the Department finds that, because of the significantly greater sample size used in the billing analysis, the savings estimates resulting from the billing analysis are a more reliable indicator of program savings than the savings estimates resulting from the end-use metering. In addition, the Department finds that, by using stratified participant and comparison groups in the billing analysis, the Company has taken reasonable steps to ensure that the members of the comparison group have characteristics similar to the members of the participant group. Thus, the Department finds that the Company has taken reasonable steps to ensure that the energy savings estimates are sufficiently unbiased. In addition, the Department finds that, by including a large number of 1991 program participants and twice as many non-participants as participants in the billing analysis, the Company has taken reasonable steps to ensure that the savings estimates were measured to a sufficient level of precision.[83]

The record demonstrates that the Company developed capacity savings estimates for the Small C/I Program based on the results of its end-use metering activities, adjusted for savings persistence and free-ridership factors. The Department previously has found that end-use metering is a "good data source" for determining capacity savings estimates. BECo

---

[83] The Department notes that, because the precision of savings estimates produced by a billing analysis is, in large part, dependent on the billing data of the customers included in the participant and comparison groups, the level of precision cannot be determined in advance of the analysis.

at 107. The Department has identified poor selection of samples used in savings measurement analyses, overestimated savings persistence, and failure to account for free riders as three sources of bias in savings estimates. Id. at 110-112; WMECo at 138. The Department finds that the Company, through (1) the selection of metering samples that were representative of the total population of program participants, (2) on-site surveys to determine savings persistence, and (3) telephone surveys to determine free-ridership, has taken reasonable steps to ensure that the capacity savings estimates are sufficiently unbiased. The Department also finds that the capacity savings estimates were measured to a sufficient level of precision.

Based on the above analysis, the Department finds that the 1992 impact evaluation for the Small C/I Program satisfies the criteria established by the Department for the review of such evaluations. Accordingly, the Department accepts the First Look savings estimates for 1992 and the Second Look savings estimates for 1991.

C. Residential Programs

1. Residential Electric Space Heat Program

a. Description

The Company began implementation of the Residential Electric Space Heat ("RESH") Program in 1990. The program is designed to capture the electricity conservation potential of one-to-four family buildings through the installation of comprehensive ECMs at no direct cost to the customer (Exh. DPU-1, at XI-1).[84] The Company provided DSM services

[84] Measures installed include attic, basement, and wall insulation upgrades, window and (continued…)

through this program to 3,529 customers during 1992 (id.). It reported First Look annual energy savings estimates of 5,995 MWH and annual capacity savings estimates of 2,818 KW for ECMs installed during 1992 (id.). In addition, the Company reported Second Look annual energy savings estimates of 4,218 MWH and annual capacity savings estimates of 1,982 KW for ECMs installed during 1991 (id. at B-1).

The Company's 1992 impact evaluation for the RESH Program consisted of three major components: (1) post-installation engineering estimates of gross energy savings based on the number of ECMs installed; (2) a billing analysis of program participants; and (3) a demand/energy ratio for the company's residential electric space heat customers, developed from load research data (id. at XI-5).

As a first step in determining savings estimates for this program, the Company developed post-installation engineering estimates of gross energy savings using the Energy Economics of Design Options ("EEDO") software model (id.).[85] The Company stated that the EEDO model was used because it was capable of (1) modeling interactive effects of multiple measures installed in a single building and (2) providing savings estimates based on a disaggregated list of ECM types that reflected the ECMs installed through this program

---

[84](…continued)
door improvements, air sealing measures, lighting improvements, set-back thermostats and various hot water measures (Exh. DPU-1, at XI-1). The program design was revised in 1993 so that program participants are currently required to pay the costs of ventilation work that is necessary as a consequence of the installation of the attic insulation. D.P.U. 92-217, at 4.

[85] The Energy Economics of Design Options software was developed by Building Sciences Engineering in collaboration with Company staff (Exh. DPU-1, at X-5).

(id.).

To determine energy savings estimates for this program, the Company performed a billing analysis that compared the pre- and post-installation[86] energy usage data of a group of 813 customers who participated in the program during 1991 (the "participant group") with the pre- and post-installation energy usage data for a group of 201 customers selected from the list of customers waiting to participate in the program (the "comparison group") (id. at XI-6).[87] The billing analysis resulted in energy savings estimates for the sample of participants included in the participant group that were 52 percent of the engineering estimates for those same participants (id. at XI-8).[88] The Company stated that, to determine the program's net energy savings estimate, it applied an adjustment factor of 52 percent to the engineering estimates of energy savings for the entire population of 1992 participants (id.). The Company stated that it did not adjust the energy savings estimates to account for savings persistence or free riders, since the effect of these factors was accounted for in the billing analysis (id. at XI-8).

The Company determined capacity savings for this program based on a demand/energy ratio that was developed from its load research data for residential space heat

---

86 The pre-installation period was defined as January 31, 1990 through February 28, 1991; the post-installation period was defined as December 1, 1991 through January 1, 1993 (Exh. DPU-1, at XI-6).

87 The Company stated that it selected customers in the comparison group from the program's waiting list in order to reflect the self-selection tendencies of the program participants. The Company stated that the size of the comparison group was limited by the number of customers on the waiting list.

88 The Company stated that the precision level of the energy savings estimates was $\pm$40 percent, at the 90 percent confidence level (Exh. DPU-152).

customers (id.). The Company stated that the demand/energy ratio, which reflects the relationship between the contribution to peak demand by residential electric space heat customers and the total energy consumed for heating by these customers, was applied to the energy savings estimates indicated by the billing analysis (id.). The Company stated that, because the billing analysis takes into account savings persistence and free ridership, it did not further adjust the demand savings estimates to account for these factors (id. at XI-8).

b. Analysis and Findings

The record shows that the Company based its estimate of energy savings on the results of a billing analysis of 813 program participants and 201 non-participants in which the non-participants were selected from the list of customers waiting to participate in the program. The Department previously has found that billing analysis of program participants that employs a comparison group "can provide accurate estimates of energy savings at modest expense, while controlling for free riders …." MECo at 103. The Department has identified the poor selection of samples used in savings measurement analyses as a source of bias in the savings estimates produced by the analyses. WMECo at 138. The Department finds that, by selecting the members of the comparison group from the list of customers waiting to participate in the program, the Company has taken reasonable steps to ensure that the members of the comparison group have similar characteristics to the members of the participant group. Thus, the Department finds that the Company has taken reasonable steps to ensure that the energy savings estimates produced by the billing analysis are sufficiently unbiased. In addition, the Department finds that, by including a large number of 1991 program participants and as many non-participants as could be identified from the program's

waiting list, the Company has taken reasonable steps to ensure that the savings estimates were measured to a sufficient level of precision.

The record shows that the Company developed capacity savings estimates based on load-shape data for residential electric space heat customers that was applied to the energy savings estimates produced by the billing analysis. The Department previously has found that the use of load-shape data, in combination with billing analysis, "is potentially much less expensive than large-scale end-use metering and is largely based on actual data" MECo at 108-109 and, thus, "provides an adequate basis … for estimating" capacity savings BECo at 108. The Department finds that, because the load-shape data were applied to energy savings estimates that were found to be sufficiently unbiased and measured to a sufficient level of precision, the capacity savings estimates produced by the load-shape data are similarly sufficiently unbiased and precise.

Based on the above analysis, the Department finds that the 1992 impact evaluation for the RESH Program satisfies the criteria established by the Department for the review of such evaluations. Accordingly, the Department accepts the First Look savings estimates for 1992 and the Second Look savings estimates for 1991.

2. Residential Lighting Program

a. Description

The Company began implementation of the Residential Lighting Program ("RLP") in 1991 (Exh. DPU-1, at X-1). The purpose of the RLP is to reduce residential electricity use through the installation of high efficiency lighting in homes. The Company markets the program by offering discounted compact fluorescent lamps ("CFLs") through a mail order

catalog and through rebates for CFLs purchased at participating retail stores in the Company's service territory (id.). The end-use technologies delivered through the program were seven types of screw-in CFLs that replace incandescent lamps of up to 100 watts. The Company reported that 52,833 participants received CFLs in 1992 (id. at X-1).

The Company determined energy savings estimates for the program using a four-step process. First, the Company determined the total number and type of CFLs sold in its service territory. Second, the Company installed small metering devices, lighting loggers, to record hours-of-use of CFLs in 134 of the homes visited (id. at X-8). Third, the Company visited the homes of 202 participants to perform on-site evaluations of lighting persistence and displaced wattage for installed CFLs (id. at X-2, X-6, X-7).[89] Fourth, it performed a telephone survey of approximately 500 customers to determine the number of households that would use CFLs absent the Company's CFL program and thus represent free riders (id. at X-2).

The Company stated that demand savings were calculated by a three-step process using some of the components of the energy savings calculation. Using the previously described number of CFLs purchased, displaced wattage, measured persistence, and free rider estimates, the Company calculated demand savings using the coincidence factor from the results of its lighting-logger measurements (id. at X-5).

---

89 The persistence rate was determined by on-site surveys which showed the percentage of CFLs which were 1) installed and in place, 2) not installed but would be installed within one year, 3) installed but removed, or 4) not installed and would not be installed within one year (Exh. DPU-1, at X-7).

Total lifetime energy savings estimates for 1992 participants were 74,402 MWH, representing a 29 percent decrease from preliminary 1992 year-end estimates (id. at X-1).[90] Similarly, estimates of demand savings for 1992 participants were 17,889 KW, representing a 46 percent decrease from preliminary 1992 year-end engineering estimates. The Company stated that the downward revision from preliminary estimates was due to several factors: (1) displaced wattages were lower than preliminary estimates; (2) out-of-service rates were higher than preliminary estimates; (3) hours-of-use were lower than preliminary estimates; and (4) diversity factors were lower than preliminary estimates. Final estimates of program impacts are 200 KWH annual savings and 0.048 KW capacity savings per household (id. at X-1).

1991 Residential Lighting savings were revised to reflect two-year persistence data and improved hour-of-use and diversity data from the 1992 program evaluation (id. at XIII-11). Based on the updated estimates, the Company decreased its First Look estimates by 30 percent for energy savings and 47 percent for capacity savings for measures installed during 1991 (id. at XIII-11). The Company reported that persistence data accounted for most of the decrease in each estimate (id.).

b. Analysis and Findings

The record shows that the Company has presented estimates of energy and capacity savings based on after-the-fact measurement techniques such as extensive customer surveys, on-site inspections of CFLs at customers' homes, and measured savings estimates using

---

90 The Company determined that participation in this program in 1992 increased by 257 percent and that total CFL sales increased by 673 percent (id. at X-2).

lighting loggers. The Department finds this combined approach to estimating savings for this program to be commendable. The Department notes that the use of lighting loggers, in particular, rather than reliance on the previous method of customer self-reporting, is a highly appropriate after-the-fact measurement technique for estimating energy and capacity savings from CFLs. Therefore, the Department finds that the Company's savings estimates for this program are sufficiently unbiased. The Department accepts the Company's estimates of energy and capacity savings for the RLP for 1991 and 1992.

3. Home Energy Management Program

a. Description

The Home Energy Management Program, initiated in 1990, was designed to reduce the Company's peak demand by controlling the operation of residential electric water heaters for either six hours ("the six-hour group") or 16 hours ("the 16-hour group") during peak periods (Exh. DPU-1, at VIII-1). The Company stated that it controls electric water heaters using radio signals or time clocks, which automatically turn off the water heaters at times of system peak demand.[91] The Company served a total of 3,813 customers in 1992 with participating customers receiving fixed monthly credits on their bills (id. at VIII-1).

---

91 The Company defined its winter system peak period for the six-hour group as 9:00 AM to 12:00 PM and from 5:00 PM to 8:00 PM, and for the 16-hour group from 7:00 AM to 11:00 PM (Exh. DPU-1, at VIII-5, VIII-7). The Company stated that its system peak typically occurs in the winter between 5:00 PM and 7:00 PM (id. at VIII-5).

The Company determined demand savings estimates based on special meters installed on water heaters at 107 participants' homes (id. at VIII-4).[92] Water heaters at the sample of 107 homes were controlled on one day, then not controlled the next, over a series of days (id. at VIII-5). The analysis consisted of measuring the difference in energy usage by those water heaters on controlled and uncontrolled days (id. at VIII-5, VIII-6). The difference in energy use between controlled and uncontrolled days was divided by the number of controlled hours to estimate the demand savings (id.). The Company reported per-customer savings estimates of 0.52 KW in the morning and 0.58 KW in the afternoon for the six-hour group, and savings estimates of 0.35 KW and 0.30 KW for the 16-hour group (id. at VIII-7).[93] The Company noted that the average estimated KW savings per customer were 26 percent higher than the previous year's savings estimates, which were based on two smaller samples representing 39 participants (id. at VIII-8, VIII-4). The Company reported total lifetime demand savings estimates of 1,927 KW for 1992 installations (id. at VIII-1).[94]

b. Analysis and Findings

The record indicates that the Company determined demand savings for this program using end-use meters. The record also indicates that the Company took steps to ensure that

---

92 The Company stratified the groups receiving the measurement meters into three groups according to household type and size so that the measurements would be representative of other program participants (Exh. DPU-1, at VIII-4).

93 The Company reported the following precisions for the demand savings at the 90 percent confidence level: ± 11 percent for the six-hour group and ±23 percent for the 16-hour group (Exh. DPU-1, Appendix C at 2).

94 The Company reported 1991 total lifetime demand savings of 39,308 KW (Exh. DPU-1, at XIII-2).

the groups selected for end-use metering were stratified to be representative of the entire group of program participants. The Department finds the savings estimates are sufficiently unbiased and that the Company's method achieves a reasonable level of precision. Accordingly, the Department accepts the Company's 1992 demand savings estimates from the HEM Program.

4. Multi-Family Program

a. Description

The Company began implementing its Multi-Family Program through pilot programs in 1990 and 1991 (Exh. DPU-1, at IX-1). Through participation in this program, public and private residential facilities that are electrically heated and consist of more than five dwelling units receive comprehensive electricity conservation measures (id. at IX-1).[95] The Company reported that the program was only fully operational during the last four months of 1992 and that 728 customers in 13 Multi-Family facilities received services.

The Company stated that, because the program was not fully operational until the last four months of 1992, there were insufficient post-installation data to conduct a full billing analysis (id. at IX-4). Therefore, the Company stated that it initially attempted to develop impact evaluations for this program using an analysis of billing data from 18 multi-family facilities treated between July 1990 and September 1991 that were part of the Multi-Family Pilot Program. However, during the course of the billing analysis, the Company stated that

---

95 The DSM measures delivered to participants include insulation, windows, high efficiency lighting fixtures and lamps, air sealing, hot water measures, setback thermostats, and custom measures (Exh. DPU-1, at IX-1).

it found that 1992 program participants were dissimilar to the 1991 pilot participants in a number of important respects.[96] The Company stated that because of the differences between the pilot program participants and the actual 1992 Multi-Family program participants, it determined that the most accurate method of transferring the results of the pilot program billing analysis to the 1992 participants would be to apply the average savings per housing unit in the pilot program, 880 KWH per dwelling unit, to 1992 units. The Company compared the average unit estimate with the results of building simulation models developed by the Company and found that the savings estimate was 42 percent lower than the building simulation model results (id. at IX-5). The Company, therefore, indicated that the 880 KWH/unit estimate was an appropriate proxy value and that it was well within the expected savings range (id.).

Accordingly, to determine energy savings estimates for the 1992 Multi-Family program, the Company applied the 880 KWH/unit savings estimate developed in the pilot program to the 728 units treated in 1992. To determine demand savings estimates for the program, the Company applied a KW/KWH ratio developed from load research for all residential customers with electric heat (id. at IX-5).

---

96 The specific differences between the 1991 pilot participants and the 1992 Multi-Family Program participants were discrepancies in (1) meter types (master metered facilities vs. individually metered housing units); (2) the percentage of facilities that were condominiums; (3) tenant demographics and incomes; (4) the number of housing units per facility; and (5) installed ECMs (Exh. DPU-1, at IX-4).

b. Analysis and Findings

The record demonstrates that the Company performed installations during the last four months of 1992 only, and that there were insufficient data to use as the basis for a billing analysis for the entire year. The record further demonstrates that, because of differences between treated dwelling units in 1991 and 1992 (such as differences in building types, metering configurations, tenant demographics, and installed ECMs) the Company determined that it would be inappropriate to apply 1991 unit-specific savings estimates to units treated in 1992. Instead, the Company based 1992 savings estimates on the average savings per housing unit in the pilot program. While the data available to the Company for analysis of 1992 program savings were limited, for the purposes of this proceeding, the Department accepts the savings estimates as sufficiently unbiased. However, as the Company fully implements the program in future years, the Company is expected to perform a more comprehensive billing analysis.

5. Energy Fitness Program

a. Description

The Energy Fitness Program originally was implemented by the Company in 1989-1991 through a neighborhood-based delivery system that targeted low-income residents. In 1992, the Energy Fitness program was combined with the Energy Conservation Service energy audit program to broaden program participation (Exh. DPU-1, at VII-1). The program was also expanded in 1992 to target a wider variety of customers, rather than focus on low-income residents. The goal of the current program is to install ECMs in the homes of customers who have requested an ECS audit, regardless of the heating source for their

home. The Company stated that, during 1992, it installed an average of 2.5 CFLs in households visited, which was down from the 5.5 installations per household of the previous year (id. at VII-4). Contractors implementing the Energy Fitness program also cleaned any air conditioner filters and accessible refrigerator coils, and wrapped hot water tanks (id. at VII-1 and App. A at A-33).

The Company stated that, because it expected savings from ECMs installed to be very small compared to total energy use, it determined that a billing analysis was unlikely to yield statistically significant results (id. at VII-4).[97] Therefore, the Company calculated energy savings as the product of (1) the number of CFLs installed, (2) the KW savings per CFL based on the number of watts displaced by each retrofit, (3) hours-of-use for each lighting installation,[98] (4) a 15 percent removal rate (persistence) adjustment,[99] and (5) a 4.55 percent free-rider adjustment (id. at VII-5, A-33). Based on this five-step process, savings estimates increased 81 percent for the 13-watt CFLs and 52 percent for the 22-watt CFLs (id., App. A at A-32; App. B at B-28).

---

97 For 1991 installations, the Company's billing analysis estimated a realization rate of 41 percent, based on a sample of 2,235 participants (Exh. DPU-1, App. C at 2). The precision level at the 90 percent confidence interval was $\pm$45 percent (id.).

98 Hours-of-use values were determined using lighting loggers, which measured 1,087 average hours-of-use for installed CFLs at selected homes (Exh. DPU-1, at VII-6). The Company stated that it revised the lifetime estimated in years upward to be consistent with the hours-per-year results (id. at VII-5).

99 Using surveys, the Company found that 15 percent of the CFLs installed through the program were not installed or were no longer in service (Exh. DPU-1, at VII-2, VII-3, A-33, B-28).

To calculate demand savings from lighting installations, the Company used a five-step calculation similar to that used to calculate energy savings, except that summer and winter diversity factors were used while hours-of-use were not used (id. at VII-5). The winter diversity factor was based on data from the lighting loggers, while the summer diversity factor was based on customer estimates of the time of day that CFLs were used (id. at VII-6).[100] The Company reported that CFLs accounted for 84 percent of estimated lifetime energy savings from 1992 program installations, and for 90 percent from 1991 program installations (id. at VII-7; App. B at B-29).

For refrigerator coil cleaning and air conditioner filters, the Company assumed that it achieved its engineering estimates of savings, derived from industry literature (id. at VII-5). For water heater wraps, the Company used engineering estimates adjusted for free-rider effects (id., App. A at A-33; App. B at B-29).

b. Analysis and Findings

The record indicates that the Company used after-the-fact measurement techniques to calculate the energy and capacity savings estimates for CFLs. The Company has adjusted its savings estimates to account for displaced wattage, free-ridership, persistence and measured hours-of-use from lighting loggers. The Department finds that the savings estimate are sufficiently unbiased. Therefore, the Department accepts the Company's estimates of lifetime energy and demand savings from 1991 and 1992 installations for the Energy Fitness

---

[100] Compared to 1991 estimates, the summer coincidence factor fell from 13 percent to 7 percent, and the winter diversity factor fell from 47 percent to 27 percent (Exh. DPU-1, at VII-5). The low diversity factors mean that most CFLs are off at times of system peak (id.; App. A at A-32).

program. Since the Company did not report the precision levels associated with its savings estimates, the Department directs the Company to report the estimated precision of its savings estimates in its next filing.

6. Water Heater Rebate Program

a. Description

The Water Heater Rebate Program was implemented by the Company from 1987 through 1993 (Exh. DPU-1, at XII-1). The goal of the program is to promote the installation of high-efficiency electric water heaters by providing $50 rebates to residential customers who purchase eligible water heaters and $20 payments to vendors for each high-efficiency electric water heater sold to Company customers (id. at XII-1). Program participation was low in 1992, serving only 417 customers, or 15 percent of the Company's goal (id.). In 1993, the program was terminated because it continued to fall short of Company goals and was determined to be no longer cost-effective.

The Company based its impact evaluation of energy savings achieved during 1991 and 1992 on two factors: (1) engineering estimates from the United States Department of Energy ("DOE") showing the difference in efficiency between high-efficiency and "base efficiency" water heaters for each tank size (id. at XII-2);[101] and (2) the number of high-efficiency units sold to Company customers (id.). The Company stated that the DOE formula was developed for the Federal Trade Commission's Appliance Labeling Program (id. at XII-2). Demand savings estimates were developed by dividing the energy savings estimates by the number of

---

[101] The Company stated that the estimate included a free-rider adjustment (Exh. DPU-1, at XII-2).

hours in the year, based on the assumption that water heater energy savings are relatively constant through the day and year (id.).

b. Analysis and Findings

The record indicates that the Company based its energy and demand savings estimates on engineering estimates developed by the DOE for the purposes of developing national appliance efficiency labels. The Department recognizes that the program's impact is very small and that the program has been terminated by the Company. Therefore, the Department finds that the use of engineering estimates to be acceptable given these circumstances. Accordingly, the Department accepts the Company's 1992 savings estimates.

7. Energy Crafted Home Program

a. Description

The Company began implementing the Energy Crafted Home ("ECH") Program in 1991. The ECH Program was developed to promote energy efficiency in new residential construction by marketing the ECH Program to builders and home buyers, and by offering training, technical assistance and financial incentives to ECH builders. The goal of the ECH Program is to capture maximum DSM savings opportunities in the new residential construction market through comprehensive, energy-efficient building practices (Exh. DPU-1, at VI-1).[102] The Company stated that it jointly implements its program with affiliates Narragansett Electric Company and Granite State Electric Company since many builders that

---

[102] The end uses addressed through the ECH program were heating, cooling, and lighting. In early 1993, the Company modified the ECH program to include rebates for high-efficiency windows, insulation, and hard-wired compact fluorescent lighting fixtures (Exh. DPU-1, at VI-1).

would be targeted by the program work in the service territories of more than one of these Companies. The Company stated that it served 16 single family and 12 multi-family customers through the ECH Program in 1992.

To perform its impact evaluation, the Company developed estimates of energy use for "base case" homes, using a specially designed software model "REM/Design."[103] The Company stated that the base case energy use estimates were developed under the assumption that base case homes would comply with Massachusetts State Building Codes (id. at VI-4).[104] Next, the Company developed energy and demand use estimates using the same REM/Design Model for individual ECH homes, adjusted for the size of the home and the interactive effects of energy savings from end uses such as air conditioning (id. at 4,5). Finally, the Company calculated final energy and demand savings estimates for the ECH Program based on the site specific "spread" in energy and demand use between base case homes and ECH homes. The Company thus determined that each ECH home could be expected to save an average of 3,976 KWH annually and 2.1 KW on peak (id. at VI-6). Total lifetime energy and demand savings estimates for installations made in 1992 were 2,806 MWH and 1,548 KW, respectively.[105]

---

103 The Company stated that it tested its model on several hundred base-case homes to refine the model (Exh. DPU-1, at VI-4).

104 In order to perform its impact evaluation for this program, the Company first inspected each participant's home to verify installation of ECMs covered by the program (Exh. DPU-1, at IV-2).

105 Lifetime savings estimates from 1991 installations were 795 MWH and 595 KW, respectively (Exh. DPU-1, at XIII-10).

b. Analysis and Findings

The record shows that the Company has based its ECH savings estimates on site-specific computer simulations of energy and capacity savings. The record also shows that the Company has used actual data on individual home sizes and has accounted for the interactive effects on energy savings from end uses such as air conditioning. In previous Orders, the Department has approved energy and capacity savings estimates that were not based on after-the-fact measurements in certain, limited circumstances. MECo at 109; BECo at 109, n.40; WMECo at 142. Further, the Department has recognized the difficulty in after-the-fact measurement techniques such as end-use metering of DSM programs that target new construction since there is no "before" consumption data to use as a baseline for savings estimates. MECo at 103, 104. Finally, the Department has recognized the expense associated with after-the-fact measurement techniques such as end-use metering and has approved of savings estimation approaches that were otherwise largely based on actual data. BECo at 108.

The Company has presented energy and demand savings calculations based on actual data and has accounted for site-specific measurements such as home sizes and end uses that affect savings levels. Therefore, the Department finds the Company's savings estimates to be sufficiently unbiased. The Department further finds that end-use metering may not be well-suited for this program since no previous consumption data exist for ECH homes and end-use metering can be an expensive M&E technique. Therefore, the Department finds that the Company properly balanced the cost of its M&E technique with the value of the precision

gained. Accordingly, the Department accepts the Company's estimates of energy and demand savings for the 1991 and 1992 ECH Program.

D. Precision of the Company's Estimates

The Company provided several estimates of the precision of the estimated savings from its combined programs, all at the 90 percent confidence level (Exh. DPU-152). Precision was not estimated for some programs or for some ECM types within programs. See Sections IV.B. and IV.C. above. Estimates of precision for total energy savings ranged from 17 percent to 34 percent, while the estimated precision for total capacity savings ranged from 4 percent to 25 percent, depending primarily on the treatment of programs for which precision was not estimated (Exh. DPU-152). The Department directs the Company to report similar estimates in the future, based on measurements for a larger fraction of its programs and ECMs.

V. ORDER

Accordingly, after due consideration, it is hereby

ORDERED: That the lifetime savings estimates reported by Massachusetts Electric Company for 1991 DSM installations are approved in part and denied in part, as set forth above; and it is

FURTHER ORDERED: That the lifetime savings estimates reported by Massachusetts Electric Company for 1992 DSM installations are approved in part and denied in part, as set forth above; and it is

FURTHER ORDERED: That the Company shall file a compliance filing simultaneously with its 1993 DSM Performance Measurement Report, to be submitted to the

Department in June, 1994. The compliance filing shall contain recalculations of the Company's 1991 and 1992 savings estimates consistent with the directives set forth in this Order. The compliance filing also shall contain recalculations of the Company's 1991 and 1992 incentives, based on the revised savings estimates; and it is

FURTHER ORDERED: That the Company shall comply with all other directives contained herein.

By Order of the Department,

_____
Kenneth Gordon, Chairman

_____
Barbara Kates-Garnick, Commissioner

_____
Mary Clark Webster, Commissioner

TABLE 2. SUMMARY OF 1992 PROGRAM SAVINGS ESTIMATES

Program	Lifetime MWH		Lifetime KW	
	Tracking	1st Look	Tracking	1st Look
Energy Initiative[1]	524,395	701,986	157,519	155,824
Design 2000[1]	381,422	352,137	85,370	83,390
Small C/I[2]	309,214	197,683	97,110	96,699
Energy Crafted Home[2]	3,026	2,806	1,401	1,548
Energy Fitness[2]	7,927	10,473	4,384	2,442
Home Energy Management[2]	0	0	22,992	28,908
Multi-Family[2]	10,049	10,891	3,786	5,119
Residential Lighting[2]	105,229	74,402	33,022	17,889
Electric Space Heat[2]	114,433	104,195	53,286	48,972
Water Heater Rebate[2]	1,508	853	172	97
TOTAL	1,457,203	1,455,446	459,042	440,887

Notes: 1. Program savings estimates must be recalculated consistent with the directives set forth in this Order.

2. Program savings estimates were accepted by the Department in this Order.

(Exh. DPU-1, at A-1).

TABLE 3. SUMMARY OF 1991 PROGRAM SAVINGS ESTIMATES

Program	Lifetime MWH		Lifetime KW	
	1st Look	2nd Look	1st Look	2nd Look
Energy Initiative[1]	1,666,116	2,141,142	531,511	490,268
Design 2000[1]	119,222	115,515	26,339	26,803
Small C/I[2]	240,080	151,233	82,656	76,586
Energy Crafted Home[2]	818	796	606	596
Energy Fitness[2]	16,228	16,228	9,638	5,912
Home Energy Management[2]	0	0	34,175	39,308
Multi Family[2]	0	0	0	0
Residential Lighting[2]	17,346	12,083	5,443	2,906
Electric Space Heat[2]	81,337	75,234	38,228	35,360
Water Heater Rebate[2]	1,114	954	127	109
TOTAL	2,142,262	2,513,185	728,724	677,846

Notes: 1. Program savings estimates must be recalculated consistent with the directives set forth in this Order.

2. Program savings estimates were accepted by the Department in this Order.

(Exh. DPU-1, at B-1).

TABLE 4. 1992 ENERGY SAVINGS FOR EI AND DESIGN 2000, BY END-USE

END-USE	EI		Design 2000	
	Annual MWH	% of Total Program Savings	Annual MWH	% of Total Program Savings
Lighting[1]	25,552	60	7,642	30
Variable Speed Drives[1]	6,970	15	7,218	31
Other Motors[2]	5,218	15	414	2
Custom & Process[1]	6,319	9	8,498	25
HVAC, Shell, Refrigeration[1]	643	1	6,471	12
TOTAL	44,702	100	30,243	100

Notes: 1. Program savings estimates must be recalculated consistent with the directives set forth in this Order.

2. Program savings estimates were accepted by the Department in this Order.

(Exh. DPU-1, at A-4, A-17).